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THE OBSERVATORY,

A

MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

VOL. IX.

LONDON:
TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.
1886.

Meteors, Trained, 131.
—— with Shifting Radiants, 103.
—— with Stationary Radiants, 74.
Minor Planets, 79, 111, 142, 207, 238, 272, 296, 320, 371, 403.
—— ——, Influence of Phase on brightness of, 270.
Monck, Brorsen's Comet (1846), 229.
——, Comets and Meteors, 331.
——, Companion Comets, 279, 309.
——, Meteors with Shifting Radiants, 103.
——, Meteors with Stationary Radiants, 74.
——, Previous Visits of Periodic Comets, 259.
——, Telescopic Meteors and the height of the Atmosphere, 356.
——, Trained Meteors, 131.
Moon, Changes in Radiation of Heat from, during Eclipse, 142.
——, Handy Map of, 369.
——, Temperature of the Surface of, 141.
Morrison, Elements of Comet 1885 *e* (Barnard), 157.

Nebula, The Great, in Andromeda, 99, 192, 402.
——, The Maia, 201.
Nebulæ and Clusters, Remarkable, 43.
—— in Hercules, 164.
Neilsen, δ Cygni, 329.
Neison, Commensurability of Mean Motions in a System, 72.
Neptune, An observation of, in Lamont's Zones, 167.
——, Ephemeris for, 17.
—— —— for Satellite of, 30.
Newcomb, On a Generalized Theory of the Combination of Observations so as to obtain the best results, 369.
Newton and his Niece, 108.
Newtonian Reflectors, Method of Collimating, 349.
Noble, Proposed change in the Astronomical Day, 258.
——, Universal Time, 312.
Nova Andromedæ, 94, 109, 172, 204, 233.
—— Orionis, Gore's, 78, 402.
Numsen, Mira Ceti, 160.
Nutation Formulæ, 197.
——, Secular, of Earth's Axis, 205.

Obliquity of Ecliptic and Precession, General Values of, 150.
Observatories, Austrian, 134.
——, Continental, 358.
——, Popular Fallacies about, 389.
Observatory, Berlin, 358.
Observatory, Bonn, 358.
——, Dresden, 358.
——, Geneva, 358.
——, Greenwich, 260.
——, Harvard College, 173.
——, Hong Kong, 319.
——, Leander McCormick, 400.
——, Leiden, 138.
——, Lick, 370.
——, Lund, 358.
——, Madras, 237.
——, McGill College, 319.
——, Melbourne, 267.
——, Milan, 359.
——, Munich, 359.
——, Natal, 400.
——, New, in Belgium, 206.
——, ——, in Hungary, 135.
——, ——, in Indiana, 109.
——, ——, in La Plata, 360.
——, Oxford University, 263.
——, Paris, 169.
——, Potsdam, 169.
——, Prague, 134, 359.
——, Pulkowa, 106, 401.
——, Rio de Janeiro, 371.
——, Rousdon, 205.
——, Strassburg, 293.
——, Washburn, 343.
——, Washington, 137, 200.
——, Yale College, 235, 317.
——, Zurich, 359.
Occultation Cycle, 102.
Occultations of Stars by the Moon in 1886, 18.
Olbers' Periodical Comet, 79.
70 Ophiuchi, The binary star, 199.
Oppenheim, H., Elements and Ephemeris of Comet 1885 *d* (Fabry), 112, 143, 176, 239.
——, Elements and Ephemeris of Comet 1885 *e* (Barnard), 176, 208.
——, Elements and Ephemeris of Comet 1885 *f* (Brooks 2), 111, 143.
——, Elements and Ephemeris of Comet 1886 *a* (Brooks 1), 239.
——, Elements and Ephemeris of Comet 1886 *c* (Brooks 3), 272.
——, Elements and Ephemeris of Comet 1886 *e* (Finlay), 371.
Oppenheim, S., Ephemeris of Comet 1885 *d* (Fabry), 208.
——, Elements and Ephemeris for Comet 1886 *c* (Brooks 3), 272.
——, Elliptic elements for Comet 1886 *c* (Brooks 3), 320.
Oppolzer's Treatise on Orbits, A French Edition of, 198.
Oxford Uranometria, The, 68.
Oxygen, Absorption-spectrum of, 271.

Parallax of Nova Andromedæ, 204.
—— of ψ^2 Aurigæ, 237.
Parkhurst, The Wedge Photometer, 132.
Perry, Jevon, δ Cygni, 301, 330.
Perry, S. J., Chromosphere in 1885, 97.
Phase, influence of, on minor planets, 270.
Photograph of the Normal Solar Spectrum, 203.
Photographic determinations of Stellar positions, 321.
Photographs of Stellar Spectra exhibiting bright lines, 360.
Photography and the Pleiades, 194.
——, Stellar, 170, 203.
Photometer, Wedge, 62, 132.
Pleiades, the, 194, 396.
Pons' First Cometary discovery, 336.
Porter, Lalande, 6938, 287.
——, Proper Motion in a faint star, 288, 332.
Precession, On the General Values of the Obliquity of the Ecliptic and, 150.
Pritchard, The Wedge Photometer, 62.
——, The R. A. S. Council, 133.
Pritchett, Eclipse of Jupiter's fourth Satellite, 1886 April 30, 232.
——, Nova Andromeda, 233.
Proper Motion of Lalande 27026, 271.
—— —— Lalande 6938, 287.
—— —— of a faint star, 288, 332.
Pulkowa Observatory, 106, 401.
—— Great Refractor, 107.
—— Catalogue of Stars for 1855, 359.
L^2 Puppis, 302.

Rainband, The, 315.
Reflection Observations, Method of supporting a Mercury trough for, 110, 333.
Refraction, Method of Correcting for differential, 294.
Rio de Janeiro Observatory, 371.
Rousdon Observatory, 205.
Royal Astronomical Society Council, 110, 133.
—— —— —— Meetings, 49, 81, 113, 145, 177, 209, 241, 373.
Royer and the Constellations, 313.

S*adler*, δ Cygni, 305.
——, Lalande 10063, 356.
Safford, Groombridge's Right Ascensions, 71.
10 Sagittæ, 402.
Saturn, 74.
——, Ephemeris for, 17.
——, Ephemeris for Satellites of, 24.
——, Satellites of, 357.
Saturn's Rings, Stability of, 136.
Sawyer, Biela Meteors, 1885, 95.
——, New Variable, 398.
Saxby, The late Rev. H. S., 318.
Schulhof's Researches on the orbit of Comet 1873, 111.
Sextant, Invention of, 320.
Shearmen, On some results of photographing the Solar Corona, 355.
Sirius, Observations of Companion of, 294.
Solar System, Motion of, in Space, 171.
Spectra, Gaseous, under high dispersion, 295.
——, Stars with remarkable, 44.
——, Stellar, Bright lines in, 79.
——, ——, Exhibiting bright lines, 360.
Spectrum, Absorption, of Oxygen, 271.
—— and Aurora, 311.
——, Thollon's Map of Solar, 367.
Spitta, Method of Collimating Newtonian Reflectors, 349.
——, Satellites of Jupiter, 102.
——, Transits of Jupiter's Fourth Satellite, 161.
Star-cluster, 22 Messier, 163.
Star-Guide, The, 168.
Stars, Distribution of, in Schönfeld's 'Duchmusterung,' 391.
Strassburg Observatory, 293.
Sun, Ephemeris for Physical Observations, 31.
Sutton, Algol's Hypothetical Satellite, 286.
Svedstrup, Ephemeris for Comet 1886 *f* (Barnard), 404.

Talmage, C. G., The late, 175.
Tarrant, δ Cygni, 308.
——, 31 Messier, Andromedæ, 397.
Tebbutt, η Argûs, 194.
Telescopes, Large *v.* Small, 92, 274, 328.
——, Performance of, 334.
Terby, δ Cygni, 305, 352.
——, Performance of a Telescope, 334.
——, Pleiades and ϵ Lyræ, 396.
Thollon's Map of the Solar Spectrum, 367.
Time Reform in Japan, 343.
Trans-Neptunian Planet, Search for, 78.
Trouvelot, Photographing the Corona without an Eclipse, 394.

Universal Time, 174, 265, 266, 288, 312.
Uranus, Ephemeris for, 17.
——, Ephemeris for Satellites of, 29.

Variability of 34 Cygni, The former, 314.
Variable Star, New, 333, 398.
—— ——, A remarkable, 78.
—— ——, Probable new, 370.
—— ——, T Aquilæ, 122.
—— ——, η Argûs, 101, 194, 195.
—— ——, L² Puppis, 302.
—— ——, S Vulpeculæ, 124.
—— Stars, Maxima and Minima of, in 1885, 120, 158, 159.
—— ——, Maxima and Minima of, in 1886, 37.
—— ——, Mean Place of, 1886·0, 36.
—— —— of the Algol type, Minima of, 39.
—— —— of Short period, not of the Algol type, Minima of, 42.
—— ——, Notes on, 235, 271, 318, 344.
Venus, Ephemeris for, 15.
——, Observations of, in 1884–85, 206.
——, Occultations of, by the Sun, 332.
S Vulpeculæ, 124.

Wagner, August, the late, 403.
Washburn Observatory, Public 343.
Washington Observatory, 137, 2
Watch and Clockmaker's Handboo
Wesley, Hyginus N, 104.
Williams, η Argûs, 195.
——, Nature of the Red Spot on J and the Relative Heights of Markings, 231.
——, Variable Star, L² Puppis, 3
Wilson, Binary Star, γ Coronæ Au 234.
——, Personal Errors in Doubl Observations, 297.

Yale College Observatory, 235.
Yendell, δ Cygni, 329.
Young, Large Telescopes *v.* Smal 328.

Zodiacal Light, 196.
Zone Observations of the Astronon Gesellschaft, 270.

ENGRAVINGS.

Apparent Orbits of the Seven Inner Satellites of Saturn ....
Apparent Orbit of Iapetus ....
Apparent Orbits of the Satellites of Uranus ....
Apparent Orbit of the Satellite of Neptune ....
Sketch of the Great Nebula in Andromeda ....
Hyginus N ....
Diagram, Change in the path of a Meteor ....
Diagram, Obliquity of the Ecliptic ....
Radiant-points of the Geminids ....
Jupiter, 1886 April 9ᵈ 10ʰ 12ᵐ ....
Brooks' Second Comet, 1886..........................
Adjustment of a Newtonian Reflector ....

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E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

Titlepage and Index to Volume VIII.

	Page
duction	1
dar, including Rising and Setting of the Sun and Moon, and Meteor Notes	2–13
meris for Mercury	14
meris for Venus	15
meris for Mars	16
meris for Jupiter	16
meris for Saturn	17
meris for Uranus	17
meris for Neptune	17
ltations	18–20
emeris for Satellites of Mars	21
pses of Jupiter's Satellites	22, 23
emeris for Satellites of Saturn	24–28
emeris for Satellites of Uranus	29, 30
emeris for Satellite of Neptune	30
emeris for Physical Observations of the Sun	31
emeris for Physical Observations of Mars	32
emeris for Physical Observations of Jupiter	33–35
ipses in 1886	35
an Places of Variable Stars for 1886·0	36
ima and Minima of Variable Stars	37, 38
ima of Variable Stars of the Algol type	39–41
ima of Variable Stars of Short Period not of the Algol type	42, 43
markable Nebulæ and Clusters	43
rs with Remarkable Spectra	44, 45
ary Stars	45, 46
Hundred noteworthy Double Stars, Test-objects, &c.	47, 48

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THE OBSERVATORY,

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and T. Lewis, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpo nomical Societies; Articles by various eminent Astronomers, American, and Continental; Correspondence on topics of interest o with the Science; Notes on the progress of Astronomy; Reviews nomical publications; Ephemerides of comets, variable stars, satellites, and for physical observations of the Sun, Jupiter, &c.; the usual astronomical information.

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CONTENTS OF No. 104.

Meeting of the Royal Astronomical Society on November 13, 1885 ....

Articles:—

The Greenwich System of Sympathetic Clocks and the Distribution of Ti signals. By T. Lewis, F.R.A.S. ....
Est-il opportun de changer le Mode de compter le Jour en Astronon By E. Gautier ....
Remarks on Dr. Wilsing's Experimental Examination of the Wedge Ph meter. By the Rev. Prof. C. Pritchard, F.R.S. ....
Kayser on the Spectroscope. By the Rev. Stephen H. Saxby, M.A., F.R.

Correspondence:—

Meteors with Fixed or Stationary Radiants. By W. H. S. Monck..........
Halley's Southern Catalogue, reduced by Sharp. By W. T. Lynn, B F.R.A.S. ....
Cornelius Gemma and the Star of 1572. By W. T. Lynn, B.A., F.R.A.S.
The Red Star Schjellerup 238. By J. E. Gore, M.R.I.A. ....
The Lick and Washburn Observatories. By Prof. E. S. Holden, For. As R.A.S. ....
Hyginus N. By E. Neison, F.R.A.S. ....

Notes:—

Stellar Photometry.—The Lick Observatory.—Third Report of the Co mittee on Standards of Stellar Magnitudes.—The Great Pulkowa fractor.—The Rotation Period of Mars.—Hongkong Observatory.—D little's 'Practical Astronomy.'—The Latitude of the Bordeaux Obs vatory.—Apparent Enlargement of Celestial Objects near the Horizon Commensurability of Motions.—The Biela Meteor-Shower.—The N Star in the Great Nebula in Andromeda.—The Nice Observatory.—T Dearborn Observatory.—The Wedge Photometer.—A Printing Chro graph.—The late J. Hartnup, F.R.A.S. ....

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THE OBSERVATORY,

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No. 105. 1886. Vol. IX.

INTRODUCTION.

In resolving to give in a collected form the whole of those Ephemerides which they have hitherto printed month by month in the 'Observatory,' the Editors feel that they are making somewhat of an experiment, and one which they are anxious to make as successful as possible. They would therefore ask for suggestions for the improvement of future 'Companions,' and for criticisms on the present one; as, though its preparation has cost no small thought and labour, it was undertaken too late for it to be possible to consult the Subscribers as to the details which would best meet their needs and wishes. The same reason—the lateness of the inception of the work—has rendered it impossible to complete it before the beginning of the New Year; in future it is intended to issue it with the December number or before.

The principal sources from whence the Ephemerides have been derived are as follows:—The Meteor Notes have been taken principally from the valuable series of papers by Mr. Denning in Vols. I., II., & III. of the 'Observatory' supplemented from the British Association Reports. Mr. Denning has also kindly revised them. The Ephemerides for the physical observations of Jupiter and Mars are derived by permission from those calculated by Mr. Marth, and published by the Council of the Royal Astronomical Society in the 'Monthly Notices.' The Ephemerides for the Satellites of Mars, Saturn, Uranus, and Neptune are taken from the 'American Nautical Almanac,' corrected, in some cases, for recent observations made at Greenwich. The elements of occultations and times of eclipses of Jupiter's Satellites are extracted from the English 'Nautical Almanac.' The Catalogue and Ephemerides of Variable Stars are derived from the 'Annuaire du Bureau des Longitudes;' and the Editors would take this opportunity of thanking M. Loewy for his courtesy in forwarding advance sheets of that publication.

In all cases Greenwich Mean Time is used, and the astronomical day is reckoned from noon to noon as in previous years.

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Si Ti
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.		
				h m	h m	h m	h m	h m s	h
1	1	F	·0000	4 2	20 8	17 10	21 47	0 3 53	18
2	2	S	·0027	4 3	20 7	18 6	22 36	4 21	
3	3	**S**	·0055	4 4	20 7	18 58	23 24	4 49	
4	4	M	·0082	4 5	20 6	sets	......	5 16	18
5	5	Tu	·0110	4 6	20 6	4 42	0 12	5 43	19
6	6	W	·0137	4 7	20 6	5 38	0 59	6 10	
7	7	Th	·0164	4 8	20 5	6 39	1 45	6 36	
8	8	F	·0192	4 9	20 5	7 40	2 29	7 2	
9	9	S	·0219	4 11	20 4	8 41	3 13	7 27	
10	10	**S**	·0246	4 13	20 3	9 47	3 56	7 51	
11	11	M	·0274	4 14	20 2	10 49	4 40	8 15	
12	12	Tu	·0301	4 16	20 1	11 54	5 24	8 38	
13	13	W	·0329	4 17	20 0	13 2	6 10	9 1	
14	14	Th	·0356	4 19	20 0	14 11	6 58	9 23	
15	15	F	·0383	4 20	19 59	15 22	7 50	9 44	
16	16	S	·0411	4 21	19 58	16 33	8 45	10 5	
17	17	**S**	·0438	4 22	19 58	17 39	9 44	10 24	
18	18	M	·0465	4 23	19 57	18 40	10 46	10 44	
19	19	Tu	·0493	4 24	19 56	19 31	11 48	11 2	
20	20	W	·0520	4 26	19 55	rises	12 50	11 20	19
21	21	Th	·0548	4 27	19 54	6 33	13 49	11 36	20
22	22	F	·0575	4 29	19 52	7 53	14 45	11 53	
23	23	S	·0602	4 31	19 51	9 12	15 39	12 8	
24	24	**S**	·0630	4 33	19 50	10 28	16 30	12 23	
25	25	M	·0657	4 35	19 48	11 42	17 19	12 36	
26	26	Tu	·0684	4 37	19 47	12 51	18 8	12 49	
27	27	W	·0712	4 39	19 45	13 59	18 57	13 2	
28	28	Th	·0739	4 40	19 43	15 2	19 45	13 13	
29	29	F	·0767	4 42	19 42	16 1	20 33	13 24	
30	30	S	·0794	4 44	19 40	16 54	21 21	13 33	
31	31	**S**	·0821	4 46	19 39	17 42	22 9	0 13 43	20

	d h m		d h m
New Moon	4 19 44	First Quarter	13 0 24
Full Moon	19 19 45	Last Quarter	26 13 31

Meteor Notes.

There are a large number of considerable showers visible during this
the most important being the *Quadrantids*. The principal days on wh
large meteors, commonly called fireballs, may be expected are Jan. 2, 15,
and 28.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	F
	°	°			°	°	
January	0	+90	Polaris.	Jan. 1–25	181	+35	Max.
Dec. 20–Jan. 30	21	+56	δ Cassiopeiæ.	Jan. 6–29	200	+55	ζ Ur
January 5–12...	57	−12	Large slow meteors.	Jan. 20	220	+52	Qua
				Jan. 2–3.........	231	+49	*Qua*
Dec. 20–Feb. 6..	65	+20	Max. Dec. 24.	Jan. 4–17	295	+53	Brig
Jan. 1–Feb. 9...	135	+40	Max. Jan. 25–31.				te

FEBRUARY 1886.

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.		
				h m	h m	h m	h m	h m s	h m s
32	1	M	·0849	4 47	19 38	18 22	22 56	0 13 51	20 46 28
33	2	Tu	·0876	4 49	19 37	18 58	23 42	13 58	50 25
34	3	W	·0904	4 51	19 35	sets	……	14 5	54 21
35	4	Th	·0931	4 54	19 33	5 32	0 28	14 10	20 58 18
36	5	F	·0958	4 56	19 31	6 34	1 12	14 15	21 2 14
37	6	S	·0986	4 58	19 29	7 36	1 55	14 20	6 11
38	7	**S**	·1013	5 0	19 28	8 41	2 39	14 23	10 7
39	8	M	·1040	5 2	19 26	9 45	3 22	14 25	14 4
40	9	Tu	·1068	5 3	19 24	10 51	4 7	14 27	18 0
41	10	W	·1095	5 5	19 23	11 57	4 53	14 28	21 57
42	11	Th	·1123	5 7	19 21	13 4	5 42	14 28	25 53
43	12	F	·1150	5 8	19 20	14 14	6 34	14 27	29 50
44	13	S	·1177	5 10	19 18	15 20	7 29	14 26	33 47
45	14	**S**	·1205	5 11	19 16	16 21	8 27	14 24	37 43
46	15	M	·1232	5 13	19 14	17 17	9 27	14 21	41 40
47	16	Tu	·1259	5 15	19 12	18 4	10 28	14 17	45 36
48	17	W	·1287	5 16	19 10	18 45	11 28	14 13	49 33
49	18	Th	·1314	5 18	19 8	rises	12 26	14 7	53 29
50	19	F	·1342	5 20	19 6	6 42	13 22	14 2	21 57 26
51	20	S	·1369	5 22	19 5	8 1	14 17	13 55	22 1 22
52	21	**S**	·1396	5 24	19 3	8 19	15 9	13 48	5 19
53	22	M	·1424	5 26	19 1	10 33	16 0	13 40	9 16
54	23	Tu	·1451	5 28	18 59	11 45	16 50	13 32	13 12
55	24	W	·1478	5 31	18 56	12 51	17 40	13 23	17 9
56	25	Th	·1506	5 33	18 54	13 52	18 29	13 13	21 5
57	26	F	·1533	5 34	18 51	14 49	19 18	13 3	25 2
58	27	S	·1561	5 36	18 49	15 40	20 6	12 53	28 58
59	28	**S**	·1588	5 37	18 47	16 22	20 53	0 12 41	22 32 55

	d h m		d h m
New Moon	3 15 15	**First Quarter**	11 14 46
Full Moon	18 6 15	**Last Quarter**	25 5 11

Meteor Notes.

There are no periodical showers of the first order during this month. The most important is the *Virginids.* The principal fireball dates are Feb. 2, 10, and 19.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
Feb. 15-25……	30	+35	β Trianguli.	Feb. 11–Mar. 3.	205	+17	η Boötis.
Feb. 9-Mar. …	75	+44	α Aurigæ.	Jan. 18–Feb. 13	226	+30	β Coronæ.
Feb. 28 ………	80	+ 6	γ Orionis.	February ……	234	+32	θ Coronæ.
Feb. 6-15 ……	131	+52	θ Ursæ Major.	February ……	236	+11	α Serpentis.
February ……	158	+29	Leo Minor.	Feb. 13 ………	260	± 0	β–γ Herculis.
February ……	175	+14	*Virginids.*	Feb. 20 ………	263	+36	ρ Herculis.
February ……	180	+56	*γ–δ Ursæ Maj.*	*Feb. 10–Mar. 7.*	280	−17	ξ Sagittarii.

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Sider Time Mea Nooi
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.		
				h m	h m	h m	h m	h m s	h m
60	1	M	·1615	5 39	18 44	16 58	21 39	0 12 30	22 36
61	2	Tu	·1643	5 41	18 42	17 32	22 25	12 18	40
62	3	W	·1670	5 43	18 39	18 1	23 9	12 5	44
63	4	Th	·1698	5 45	18 37	18 27	23 53	11 52	48
64	5	F	·1725	5 47	18 35	sets	......	11 38	52
65	6	S	·1752	5 48	18 33	6 32	0 37	11 24	22 56
66	7	**S**	·1780	5 50	18 31	7 37	1 21	11 10	23 0
67	8	M	·1807	5 52	18 29	8 43	2 6	10 55	4
68	9	Tu	·1834	5 53	18 27	9 50	2 51	10 40	8
69	10	W	·1862	5 55	18 25	10 55	3 39	10 25	12
70	11	Th	·1889	5 57	18 22	12 3	4 29	10 9	16
71	12	F	·1917	5 58	18 20	13 9	5 22	9 53	20
72	13	S	·1944	6 0	18 18	14 10	6 17	9 36	24
73	14	**S**	·1971	6 2	18 16	15 6	7 14	9 19	28
74	15	M	·1999	6 4	18 13	15 56	8 12	9 2	32
75	16	Tu	·2026	6 6	18 11	16 36	9 11	8 45	36
76	17	W	·2053	6 8	18 8	17 13	10 8	8 27	39
77	18	Th	·2081	6 10	18 6	17 45	11 5	8 10	43
78	19	F	·2108	6 12	18 3	rises	12 0	7 52	47
79	20	S	·2136	6 13	18 1	6 50	12 53	7 34	51
80	21	**S**	·2163	6 15	17 59	8 8	13 46	7 15	55
81	22	M	·2190	6 16	17 56	9 23	14 38	6 57	23 59
82	23	Tu	·2218	6 17	17 54	10 33	15 29	6 39	0 3
83	24	W	·2245	6 18	17 52	11 39	16 20	6 20	7
84	25	Th	·2272	6 20	17 50	12 39	17 10	6 2	11
85	26	F	·2300	6 22	17 48	13 32	18 0	5 43	15
86	27	S	·2327	6 23	17 46	14 19	18 48	5 25	19
87	28	**S**	·2355	6 25	17 44	14 58	19 35	5 7	23
88	29	M	·2382	6 27	17 41	15 34	20 21	4 48	27
89	30	Tu	·2409	6 29	17 39	16 4	21 6	4 30	31
90	31	W	·2437	6 31	17 37	16 31	21 50	0 4 12	0 35

	d	h	m		d	h	m
New Moon	5	10	4	**First Quarter**	13	1	17
Full Moon	19	16	37	**Last Quarter**	26	22	44

Meteor Notes.

The most favourable nights for meteor-observations are March 1–4 and Fireballs should be looked for March 5–10 and 18.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A	Dec.	Rema
	°	°			°	°	
Mar. 3–27	36	+67	ε Cassiopeiæ.	Mar. 12–April .	223	+40	β Boötis.
Mar. 1–15	50	+48	α Persei.	Mar. 27–May ...	227	− 5	β Libræ.
Mar. 20–April .	145	+51	θ Ursæ Major.	Mar. 7	233	−18	γ Libræ.
Mar. 18–19 ...	157	+13	α Leonis.	Mar. 7	244	+15	γ Herculi
March–April ...	180	+60	Well-marked shower.	Mar. 14	263	+48	*Draconids*
				Mar. 1–15	300	+80	Large slo teors.
Mar. 5–17	190	+ 1	γ–δ Virginis.				

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.		
				h m	h m	h m	h m	h m s	h m s
91	1	Tн	·2464	6 32	17 34	16 56	22 33	0 3 54	0 39 5
92	2	F	·2492	6 34	17 32	17 19	23 18	3 36	43 1
93	3	S	·2519	6 35	17 29	sets	......	3 18	46 58
94	4	**S**	·2546	6 37	17 27	6 32	0 2	3 0	50 54
95	5	M	·2574	6 38	17 25	7 40	0 48	2 43	54 51
96	6	Tᴜ	·2601	6 40	17 23	8 48	1 36	2 25	0 58 47
97	7	W	·2628	6 42	17 20	9 57	2 26	2 8	1 2 44
98	8	Tн	·2656	6 43	17 18	11 3	3 18	1 51	6 40
99	9	F	·2683	6 45	17 16	12 6	4 13	1 34	10 37
100	10	S	·2711	6 47	17 14	13 2	5 9	1 18	14 34
101	11	**S**	·2738	6 49	17 12	13 52	6 6	1 ·2	18 30
102	12	M	·2765	6 50	17 9	14 35	7 2	0 46	22 27
103	13	Tᴜ	·2793	6 52	17 7	15 11	7 58	0 30	26 23
104	14	W	·2820	6 54	17 5	15 44	8 53	0 15	30 20
105	15	Tн	·2847	6 56	17 3	16 14	9 47	0 0 0	34 16
106	16	F	·2875	6 58	17 1	16 43	10 40	23 59 45	38 13
107	17	S	·2902	6 59	16 59	rises	11 32	59 31	42 9
108	18	**S**	·2930	7 1	16 56	6 58	12 24	59 17	46 6
109	19	M	·2957	7 3	16 54	8 12	13 16	59 3	50 2
110	20	Tᴜ	·2984	7 5	16 52	9 21	14 8	58 50	53 59
111	21	W	·3012	7 6	16 50	10 26	15 0	58 37	1 57 56
112	22	Tн	·3039	7 8	16 48	11 22	15 50	58 25	2 1 52
113	23	F	·3066	7 9	16 46	12 13	16 40	58 13	5 49
114	24	S	·3094	7 11	16 44	12 57	17 28	58 2	9 45
115	25	**S**	·3121	7 13	16 42	13 33	18 15	57 51	13 42
116	26	M	·3149	7 14	16 40	14 5	19 0	57 41	17 38
117	27	Tᴜ	·3176	7 16	16 38	14 33	19 45	57 31	21 35
118	28	W	·3203	7 17	16 36	14 58	20 28	57 22	25 31
119	29	Tн	·3231	7 19	16 34	15 22	21 12	57 13	29 28
120	30	F	·3258	7 20	16 32	15 46	21 56	23 57 5	2 33 25

	d	h	m		d	h	m
New Moon	4	2	31	First Quarter	11	8	44
Full Moon	18	2	59	Last Quarter	25	17	16

Meteor Notes.

There are several good showers which may usually be expected this month. Moonlight will interfere with the *Lyrids*, one of the most interesting. The *Aquarids*, a strong shower, are visible just before daybreak. The chief fireball dates are April 2, 6, 10, 20, and 25–30.

Duration.	R. A.	Dec.	Remarks.	Duration.	R. A.	Dec.	Remarks.
	°	°			°	°	
April	194	+ 9	ε Virginis.	April 18–20 ...	274	+34	*Lyrids.*
April 1–May 25	204	+56	ζ Ursæ Major.	April 21	283	+59	ο Draconis.
April–May......	208	− 8	κ Libræ.	April 19–23 ...	284	+44	π Cygni.
April–May......	228	− 4	β Libræ.	April 19–23 ...	288	+22	β Cygni.
April–May......	240	+25	ε Coronæ.	April 19–23 ...	294	+43	δ Cygni.
Mar. 2–April 25	265	+23	Max. April 13.	April 29–May 2	326	− 2	*Aquarids.*

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Sider Time Mea Noo
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.		
				h m	h m	h m	h m	h m s	h m
121	1	S	·3285	7 23	16 31	16 10	22 42	23 56 57	2 37
122	2	**S**	·3313	7 25	16 31	sets	23 30	56 50	41
123	3	M	·3340	7 27	16 30	6 34	......	56 44	45
124	4	Tu	·3368	7 28	16 27	7 44	0 20	56 38	49
125	5	W	·3395	7 30	16 25	8 53	1 12	56 32	53
126	6	Th	·3422	7 32	16 23	9 59	2 7	56 28	2 57
127	7	F	·3450	7 34	16 20	10 59	3 4	56 23	3 1
128	8	S	·3477	7 35	16 18	11 51	4 1	56 19	4
129	9	**S**	·3504	7 36	16 17	12 37	4 58	56 16	8
130	10	M	·3532	7 38	16 15	13 15	5 54	56 14	12
131	11	Tu	·3559	7 39	16 14	13 48	6 49	56 12	16
132	12	W	·3587	7 40	16 13	14 17	7 41	56 10	20
133	13	Th	·3614	7 42	16 11	14 45	8 33	56 9	24
134	14	F	·3641	7 43	16 9	15 13	9 24	56 8	28
135	15	S	·3669	7 45	16 8	15 41	10 14	56 9	32
136	16	**S**	·3696	7 45	16 7	16 10	11 5	56 9	36
137	17	M	·3724	7 46	16 6	rises	11 57	56 10	40
138	18	Tu	·3751	7 47	16 4	8 11	12 49	56 12	44
139	19	W	·3778	7 48	16 2	9 11	13 40	56 15	48
140	20	Th	·3806	7 49	16 1	10 5	14 31	56 18	52
141	21	F	·3833	7 50	15 59	10 53	15 20	56 21	3 56
142	22	S	·3860	7 52	15 58	11 33	16 8	56 25	4 0
143	23	**S**	·3888	7 53	15 57	12 7	16 54	56 30	4
144	24	M	·3915	7 54	15 55	12 36	17 39	56 35	8
145	25	Tu	·3943	7 55	15 54	13 2	18 23	56 40	11
146	26	W	·3970	7 56	15 53	13 26	19 6	56 46	15
147	27	Th	·3997	7 57	15 52	13 50	19 50	56 53	19
148	28	F	·4025	7 59	15 51	14 12	20 34	57 0	23
149	29	S	·4052	8 0	15 50	14 38	21 20	57 8	27
150	30	**S**	·4079	8 1	15 49	15 4	22 9	57 16	31
151	31	M	·4107	8 2	15 49	15 37	23 1	23 57 24	4 35

	d	h	m		d	h	m
New Moon	3	15	43	**First Quarter**	10	14	20
Full Moon	17	13	47	**Last Quarter**	25	11	36

Meteor Notes.

There are no great periodical showers due in this month. Fireball date May 1, 13, 20, 21, and 31.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remar
	°	°			°	°	
May–June	123	+40	31 Lyncis.	May 18–June 14	273	+34	α Lyræ.
May	155	+ 9	α Leonis.	May 25	280	+54	*Draconids.*
May 16–31......	175	+64	α Ursæ Major.	May 2............	285	+12	ζ Aquilæ.
May	223	−12	α Libræ.	May 22–24......	301	+37	*Cygnids.*
May 7–18	231	+27	α Coronæ.	May–June	329	+48	Lacerta.

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.		
				h m	h m	h m	h m	h m s	h m s
152	1	Tu	·4134	8 3	15 48	16 16	23 56	23 57 33	4 39 34
153	2	W	·4162	8 4	15 48	sets	......	57 42	43 31
154	3	Th	·4189	8 5	15 47	8 50	0 53	57 52	47 27
155	4	F	·4216	8 6	15 47	9 48	1 52	58 2	51 24
156	5	S	·4244	8 7	15 46	10 37	2 52	58 13	55 21
157	6	**S**	·4271	8 8	15 46	11 18	3 49	58 23	4 59 17
158	7	M	·4299	8 10	15 45	11 53	4 45	58 34	5 3 14
159	8	Tu	·4326	8 11	15 44	12 24	5 39	58 46	7 10
160	9	W	·4353	8 13	15 44	12 52	6 31	58 57	11 7
161	10	Th	·4381	8 14	15 43	13 18	7 21	59 9	15 3
162	11	F	·4408	8 14	15 43	13 46	8 11	59 21	19 0
163	12	S	·4435	8 15	15 42	14 15	9 0	59 33	22 56
164	13	**S**	·4463	8 16	15 42	14 45	9 51	59 45	26 53
165	14	M	·4490	8 17	15 42	15 20	10 41	23 59 58	30 50
166	15	Tu	·4518	8 17	15 41	16 1	11 32	0 0 10	34 46
167	16	W	·4545	8 18	15 42	rises	12 23	0 23	38 43
168	17	Th	·4572	8 18	15 42	8 48	13 13	0 36	42 39
169	18	F	·4600	8 19	15 42	9 30	14 2	0 49	46 36
170	19	S	·4627	8 19	15 42	10 7	14 49	1 2	50 32
171	20	**S**	·4654	8 19	15 43	10 38	15 34	1 14	54 29
172	21	M	·4682	8 20	15 43	11 5	16 18	1 27	5 58 25
173	22	Tu	·4709	8 20	15 44	11 31	17 2	1 40	6 2 22
174	23	W	·4737	8 21	15 44	11 53	17 44	1 53	6 19
175	24	Th	·4764	8 21	15 45	12 17	18 28	2 6	10 15
176	25	F	·4791	8 21	15 45	12 40	19 12	2 19	14 12
177	26	S	·4819	8 21	15 46	13 6	19 59	2 32	18 8
178	27	**S**	·4846	8 21	15 46	13 35	20 48	2 44	22 5
179	28	M	·4873	8 21	15 47	14 8	21 41	2 57	26 1
180	29	Tu	·4901	8 20	15 47	14 49	22 38	3 9	29 58
181	30	W	·4928	8 20	15 46	15 40	23 37	0 3 21	6 33 55

	d h m		d h m
New Moon	2 1 55	First Quarter	8 19 27
Full Moon	16 1 39	Last Quarter	24 4 35

Meteor Notes.

There is so little real darkness during the nights at this season of the year that the work of observing meteors is rendered somewhat difficult. A fair number may, however, usually be seen. Fireball dates: June 4 and 9.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
June 1–29	168°	+55°	β Ursæ Maj.	June 7–July ...	302°	+ 8°	*Aquilids.*
June	240	+25	*Coronids.*	June 11–July 11	315	+60	*Cepheids.*
June 3–13	261	+ 5	β Ophiuchi.	June	319	+32	*Cygnids* II.
May 6–June 30.	280	+29	β Lyræ.	June–July	330	+42	*Lacertids.*
May–June 30 ...	289	+80	κ Cephei.	June 28–Aug. ..	337	+13	*Pegasids* II.

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Si Ti N N
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.		
				h m	h m	h m	h m	h m s	h
182	1	Th	·4956	8 21	15 47	7 35	......	0 3 33	6
183	2	F	·4983	8 20	15 48	8 30	0 37	3 44	
184	3	S	·5010	8 20	15 59	9 15	1 38	3 55	
185	4	**S**	·5038	8 19	15 50	9 54	2 36	4 6	
186	5	M	·5065	8 18	15 51	10 28	3 33	4 17	
187	6	Tu	·5093	8 17	15 52	10 56	4 27	4 27	6
188	7	W	·5120	8 17	15 53	11 22	5 18	4 37	7
189	8	Th	·5147	8 16	15 54	11 51	6 9	4 47	
190	9	F	·5175	8 15	15 55	12 18	6 58	4 56	
191	10	S	·5202	8 14	15 56	12 48	7 48	5 4	
192	11	**S**	·5229	8 14	15 57	13 22	8 38	5 13	
193	12	M	·5257	8 13	15 58	14 0	9 28	5 20	
194	13	Tu	·5284	8 13	15 59	14 44	10 18	5 28	
195	14	W	·5312	8 12	16 0	15 33	11 8	5 34	
196	15	Th	·5339	8 11	16 1	rises	11 57	5 41	
197	16	F	·5366	8 10	16 2	8 8	12 45	5 46	
198	17	S	·5394	8 9	16 3	8 42	13 31	5 52	
199	18	**S**	·5421	8 8	16 5	9 10	14 15	5 57	
200	19	M	·5448	8 7	16 7	9 36	14 59	6 1	
201	20	Tu	·5476	8 5	16 9	9 58	15 41	6 4	
202	21	W	·5503	8 4	16 11	10 21	16 24	6 8	7
203	22	Th	·5531	8 3	16 13	10 44	17 7	6 10	8
204	23	F	·5558	8 1	16 15	11 8	17 52	6 12	
205	24	S	·5585	8 0	16 16	11 35	18 39	6 14	
206	25	**S**	·5613	7 59	16 18	12 5	19 29	6 15	
207	26	M	·5640	7 57	16 19	12 41	20 22	6 15	
208	27	Tu	·5667	7 55	16 20	13 26	21 19	6 15	
209	28	W	·5695	7 53	16 21	14 21	22 18	6 14	
210	29	Th	·5722	7 52	16 22	15 27	23 19	6 13	
211	30	F	·5750	7 50	16 23	sets	......	6 11	
212	31	S	·5777	7 49	16 24	7 48	0 20	0 6 8	8

	d	h	m		d	h	m		d
New Moon	1	10	7	**First Quarter**	8	1	18	**New Moon**	3
Full Moon	15	15	9	**Last Quarter**	23	19	21		

Meteor Notes.

This month is usually rich in periodical showers, though the long-co twilight and the shortness of the nights still render observation difficul *Aquarids*, max. July 28, form the chief display. Fireball dates:—Jul 16, 18, 20, and 30.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	R
	°	°			°	°	
July 28–Aug....	8	+36	*Andromedes* I.	July	266	−12	σ Ser
July 20–26......	6	+59	β Cassiopeiæ.	July–Aug. 25...	28	+60	*Drac*
July 7–Aug. 4	12	+70	*f* Camelop.	July–Aug.	302	+87	*Pola*
July 30–Aug. 1	32	+51	χ Persei.	July 6–Aug. 4	310	+47	α Cy
July 23–Aug. 20	44	+56	*Perseids.*	July 27–30......	340	−13	*Aqua*
July 29–Aug....	165	+53	β Ursæ Maj.	July–Aug.	333	+26	*Pega*
July 1–11	210	+55	ζ Ursæ Maj.	July 18–Aug. 4	344	+40	Rapi tec
July 9–21	242	+68	ζ Draconis				

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.		
				h m	h m	h m	h m	h m s	h m s
213	1	**S**	·5804	7 48	16 25	8 26	1 19	0 6 5	8 40 4
214	2	M	·5832	7 46	16 27	8 57	2 16	6 1	44 1
215	3	Tu	·5859	7 44	16 28	9 27	3 10	5 57	47 57
216	4	W	·5887	7 43	16 30	9 55	4 3	5 52	51 54
217	5	Th	·5914	7 41	16 31	10 22	4 54	5 46	55 51
218	6	F	·5941	7 39	16 33	10 51	5 45	5 40	8 59 47
219	7	S	·5969	7 38	16 34	11 24	6 35	5 33	9 3 44
220	8	**S**	·5996	7 36	16 36	12 1	7 25	5 25	7 40
221	9	M	·6023	7 34	16 38	12 43	8 15	5 17	11 37
222	10	Tu	·6051	7 32	16 39	13 30	9 5	5 9	15 33
223	11	W	·6078	7 30	16 41	14 22	9 54	4 59	19 30
224	12	Th	·6106	7 29	16 43	15 19	10 41	4 49	23 26
225	13	F	·6133	7 27	16 44	rises	11 28	4 39	27 23
226	14	S	·6160	7 25	16 46	7 13	12 13	4 28	31 20
227	15	**S**	·6188	7 23	16 48	7 39	12 57	4 17	35 16
228	16	M	·6215	7 21	16 49	8 4	13 40	4 5	39 13
229	17	Tu	·6242	7 19	16 51	8 26	14 22	3 52	43 9
230	18	W	·6270	7 17	16 52	8 49	15 5	3 39	47 6
231	19	Th	·6297	7 15	16 54	9 13	15 49	3 26	51 2
232	20	F	·6325	7 13	16 55	9 39	16 34	3 12	54 59
233	21	S	·6352	7 11	16 57	10 6	17 21	2 57	9 58 55
234	22	**S**	·6379	7 9	16 58	10 38	18 12	2 42	10 2 52
235	23	M	·6407	7 7	17 0	11 18	19 5	2 27	6 48
236	24	Tu	·6434	7 5	17 1	12 8	20 2	2 11	10 45
237	25	W	·6461	7 2	17 3	13 4	21 0	1 55	14 42
238	26	Th	·6489	7 0	17 4	14 13	22 0	1 39	18 38
239	27	F	·6516	6 58	17 6	15 30	23 0	1 22	22 35
240	28	S	·6544	6 55	17 8	16 51	23 59	1 5	26 31
241	29	**S**	·6571	6 53	17 10	sets	……	0 47	30 28
242	30	M	·6598	6 51	17 12	7 24	0 55	0 29	34 24
243	31	Tu	·6626	6 49	17 12	7 53	1 50	0 0 11	10 38 21

	d	h	m		d	h	m
First Quarter	6	9	6	**Full Moon**	14	6	24
Last Quarter	22	7	42	**New Moon**	29	0	54

Meteor Notes.

August is usually the richest month in the year for meteoric displays, the *Perseids*, on Aug. 10, being the principal shower. Meteors from neighbouring radiants are usually observed from Aug. 6 to Aug. 12. Fireball dates:— Aug. 4, 10, 16, and 25.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
Aug.–Sept.	6	+11	γ Pegasi.	Aug. 6–12	96	+71	Max. Aug. 10.
August	22	+ 5	μ Piscium.	July–Aug. 6 ..	254	+37	η–π Herculis.
August	30	+36	β Trianguli.	Aug. 21–25 ...	291	+60	ο Draconis.
July 23–Aug. 20	43	+56	*Perseids.*	Aug. 10–Sept.	335	+52	ε Cephei.
Aug. 20–25 ...	53	+ 1	κ Ceti.	July 2–Aug. 16	342	−34	α Pisc. Aust.
Aug.–Sept.	74	+45	α Aurigæ.	Aug. 6–Sept. ...	359	+13	*Pegasids* III.

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Side Tim Me No
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.		
				h m	h m	h m	h m	h m s	h m
244	1	W	·6653	6 48	17 13	8 22	2 44	23 59 52	10 4
245	2	Tu	·6681	6 46	17 15	8 53	3 37	59 33	4
246	3	F	·6708	6 43	17 17	9 25	4 29	59 14	5
247	4	S	·6735	6 41	17 19	10 0	5 20	58 55	5
248	5	**S**	·6763	6 39	17 20	10 41	6 11	58 35	10 58
249	6	M	·6790	6 37	17 22	11 28	7 1	58 15	11 2
250	7	Tu	·6817	6 34	17 24	12 19	7 51	57 55	5
251	8	W	·6845	6 32	17 25	13 14	8 39	57 34	9
252	9	Tu	·6872	6 29	17 27	14 12	9 26	57 14	13
253	10	F	·6900	6 27	17 29	15 12	10 11	56 53	17
254	11	S	·6927	6 24	17 30	16 14	10 55	56 32	21
255	12	**S**	·6954	6 22	17 32	17 16	11 38	56 11	25
256	13	M	·6982	6 20	17 34	rises	12 21	55 50	29
257	14	Tu	·7009	6 18	17 35	6 55	13 4	55 29	33
258	15	W	·7036	6 15	17 37	7 17	13 47	55 8	37
259	16	Tu	·7064	6 13	17 39	7 43	14 32	54 46	41
260	17	F	·7091	6 11	17 41	8 9	15 18	54 25	45
261	18	S	·7119	6 9	17 42	8 38	16 7	54 4	49
262	19	**S**	·7146	6 6	17 44	9 15	16 58	53 43	53
263	20	M	·7173	6 3	17 46	9 59	17 52	53 22	11 57
264	21	Tu	·7201	6 0	17 48	10 53	18 48	53 1	12 1
265	22	W	·7228	5 57	17 50	11 54	19 45	52 40	5
266	23	Tu	·7255	5 54	17 52	13 4	20 43	52 19	9
267	24	F	·7283	5 51	17 54	14 22	21 41	51 58	12
268	25	S	·7310	5 49	17 55	15 42	22 37	51 38	16
269	26	**S**	·7338	5 47	17 57	17 3	23 33	51 17	20
270	27	M	·7365	5 45	17 58	sets	——	50 57	24
271	28	Tu	·7392	5 44	17 59	6 22	0 28	50 37	28
272	29	W	·7420	5 43	18 0	6 48	1 22	50 18	32
273	30	Tu	·7447	5 41	18 1	7 20	2 16	23 49 58	12 36

	d	h	m		d	h	m
First Quarter	4	[illegible]	[illegible]	Full Moon	12	22	50
Last Quarter	[illegible]	[illegible]	[illegible]	New Moon	27	9	19

Meteor Notes.

Except the fireballs, which may be looked for on September 1, 9, 15, 16, a 22, the month is not a particularly important one for meteors. Sept. 10 is t principal date.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarl
	°	°			°	°	
[illegible]	[illegible]	[illegible]	[illegible]	Sept.–Nov.	46	[illegible]	Aurigids I.
September	[illegible]	[illegible]	[illegible]	Aug.–Sept.	[illegible]	[illegible]	Lyra
[illegible]	[illegible]	[illegible]	[illegible]	Sept. 1	[illegible]	[illegible]	Cygni
[illegible]	[illegible]	[illegible]	[illegible]	Aug.–Sept.	[illegible]	[illegible]	Cygni
[illegible]	[illegible]	[illegible]	[illegible]	Sept. [illegible]	[illegible]	[illegible]	Pegasi
September	[illegible]	[illegible]	[illegible]	Aug.–Sept.	[illegible]	± [illegible]	Piscium

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.		
				h m	h m	h m	h m	h m s	h m s
274	1	F	·7474	5 38	18 3	7 57	3 9	23 49 39	12 40 34
275	2	S	·7502	5 35	18 5	8 35	4 2	49 20	44 31
276	3	**S**	·7529	5 33	18 6	9 20	4 54	49 2	48 27
277	4	M	·7557	5 31	18 8	10 11	5 45	48 43	52 24
278	5	Tu	·7584	5 29	18 10	11 4	6 34	48 25	12 56 20
279	6	W	·7611	5 27	18 12	12 3	7 22	48 8	13 0 17
280	7	Th	·7639	5 25	18 13	13 3	8 8	47 51	4 13
281	8	F	·7666	5 23	18 15	14 4	8 52	47 34	8 10
282	9	S	·7694	5 20	18 17	15 8	9 36	47 18	12 6
283	10	**S**	·7721	5 18	18 19	16 11	10 19	47 2	16 3
284	11	M	·7748	5 15	18 21	17 15	11 2	46 46	20 0
285	12	Tu	·7776	5 13	18 23	rises	11 45	46 31	23 56
286	13	W	·7803	5 10	18 24	5 47	12 30	46 17	27 53
287	14	Th	·7830	5 8	18 25	6 12	13 16	46 3	31 49
288	15	F	·7858	5 6	18 26	6 42	14 4	45 49	35 46
289	16	S	·7885	5 4	18 28	7 15	14 55	45 36	39 42
290	17	**S**	·7913	5 2	18 29	7 58	15 48	45 24	43 39
291	18	M	·7940	5 0	18 31	8 46	16 42	45 13	47 35
292	19	Tu	·7967	4 59	18 32	9 44	17 38	45 2	51 32
293	20	W	·7995	4 57	18 34	10 49	18 34	44 51	55 29
294	21	Th	·8022	4 55	18 36	12 3	19 29	44 41	13 59 25
295	22	F	·8049	4 53	18 38	13 18	20 24	44 32	14 3 22
296	23	S	·8077	4 51	18 40	14 37	21 19	44 24	7 18
297	24	**S**	·8104	4 49	18 42	15 57	22 13	44 17	11 15
298	25	M	·8132	4 47	18 44	17 16	23 6	44 10	15 11
299	26	Tu	·8159	4 45	18 45	sets	……	44 4	19 8
300	27	W	·8186	4 43	18 47	5 17	0 0	43 58	23 4
301	28	Th	·8214	4 41	18 49	5 49	0 54	43 53	27 1
302	29	F	·8241	4 39	18 51	6 28	1 49	43 50	30 57
303	30	S	·8268	4 36	18 53	7 10	2 42	43 46	34 54
304	31	**S**	·8296	4 34	18 54	7 59	3 35	23 43 44	14 38 51

	d	h	m		d	h	m
First Quarter	4	10	34	**Full Moon**	12	15	24
Last Quarter	20	2	41	**New Moon**	26	19	16

Meteor Notes.

The chief shower of October is the *Orionids*; but there are a large number of active radiants visible during the month, the principal displays taking place on Oct. 1 and Oct. 16–23. Fireball dates:—Oct. 10, 14, 18, 24, and 29.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
Oct. [illegible] and 14–20	31	+ 9	*Arietids.*	Sept. 25–Oct. 28	108	+24	*Gemellids.*
Oct. 8 and 15…	46	+26	W. of the Pleiades.	Oct. …………	105	+51	Swift, short.
				Oct. 2–19 ……	133	+79	Polaris.
Oct.-Nov. ……	78	+32	ψ Aurigæ.	Oct.–Nov. ……	133	+21	Very swift.
Oct. 17–Nov. 13	90	+15	*Orionids.*	Oct.–Nov. ……	143	+28	μ Leonis.
Sept.-Oct. ……	97	+45	*Lyncids.*	Oct. 2 …………	225	+52	Quadrans.
Oct.-Nov. ……	105	+12	β Can. Min.	Oct. 18–19……	283	+43	α Lyræ.

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Si T
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.		
				h m	h m	h m	h m	h m s	h
305	1	M	·8323	4 34	18 56	8 53	4 26	23 43 42	14
306	2	Tu	·8351	4 32	18 58	9 50	5 16	43 42	
307	3	W	·8378	4 30	18 59	10 51	6 3	43 42	
308	4	Th	·8405	4 29	19 1	11 52	6 48	43 42	
309	5	F	·8433	4 27	19 3	12 55	7 32	43 44	14
310	6	S	·8460	4 25	19 5	13 58	8 15	43 46	15
311	7	**S**	·8488	4 23	19 6	15 2	8 58	43 50	
312	8	M	·8515	4 22	19 8	16 6	9 41	43 54	
313	9	Tu	·8542	4 20	19 9	17 12	10 25	43 58	
314	10	W	·8570	4 18	19 11	18 19	11 11	44 4	
315	11	Th	·8597	4 16	19 13	rises	11 59	44 11	
316	12	F	·8624	4 14	19 15	5 15	12 50	44 18	
317	13	S	·8652	4 13	19 17	5 54	13 43	44 26	
318	14	**S**	·8679	4 12	19 19	6 42	14 38	44 35	
319	15	M	·8707	4 10	19 20	7 37	15 34	44 45	
320	16	Tu	·8734	4 9	19 22	8 40	16 30	44 56	
321	17	W	·8761	4 8	19 24	9 51	17 25	45 8	
322	18	Th	·8789	4 6	19 26	11 4	18 19	45 20	
323	19	F	·8816	4 5	19 27	12 21	19 12	45 34	
324	20	S	·8843	4 4	19 29	13 37	20 4	45 48	15
325	21	**S**	·8871	4 3	19 31	14 55	20 56	46 3	16
326	22	M	·8898	4 1	19 32	16 12	21 48	46 19	
327	23	Tu	·8926	4 0	19 34	17 28	22 41	46 36	
328	24	W	·8953	3 59	19 35	18 43	23 34	46 53	
329	25	Th	·8980	3 58	19 37	sets	......	47 11	
330	26	F	·9008	3 57	19 38	5 0	0 28	47 30	
331	27	S	·9035	3 57	19 40	5 46	1 22	47 50	
332	28	**S**	·9062	3 56	19 41	6 39	2 15	48 10	
333	29	M	·9090	3 55	19 42	7 36	3 6	48 32	
334	30	Tu	·9117	3 55	19 44	8 36	3 55	23 48 53	1

	d	h	m		d	h	m
First Quarter	3	5	5	**Full Moon**	11	7	7
Last Quarter	18	10	40	**New Moon**	25	7	19

Meteor Notes.

The two principal November showers are the *Leonids*, max. Nov. 14, *Andromedes*, Nov. 27; but the intensity of both varies greatly from year. Other well-marked showers are the *Taurids*, *Leo Minorids*, and *A*

Fireball dates:—Nov. 1, 5, 14, 20, and 29.

Duration.	R.A.	Dec.	Remarks.
	°	°	
Nov. 24–30 ...	25	+43	*Andromedes.*
Oct. 30–Nov. 1	43	+22	Slow, bright.
Nov. 25–Dec. 18	45	+33	ν Persei.
Nov. 27–30....	60	+40	ε Persei.
Oct. 25–Nov. 21	60	+18	*Taurids.*
November	[illegible]	+ [illegible]	Orionids.

Duration.	R.A.	Dec.	
	°	°	
Nov. 9	102	+75	Acti
Nov. 7	124	+ 4	δ Hy
Nov. 11–15......	149	+22	*Leon*
Nov. 15–28......	155	+40	Leo
Nov. 25–28......	208	+43	η U
Nov. 25–Dec. 9	291	+53	χ Cy

Day.			Fraction of year.	Sun.		Moon.		Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.		
				h m	h m	h m	h m	h m s	h m s
335	1	W	·9145	3 54	19 46	9 38	4 42	23 49 16	16 41 4
336	2	Th	·9172	3 54	19 47	10 41	5 26	49 39	45 0
337	3	F	·9199	3 53	19 48	11 43	6 10	50 2	48 57
338	4	S	·9227	3 52	19 49	12 46	6 52	50 27	52 53
339	5	**S**	·9254	3 52	19 50	13 51	7 35	50 51	16 56 50
340	6	M	·9282	3 51	19 52	14 54	8 18	51 17	17 0 47
341	7	Tu	·9309	3 50	19 54	16 1	9 3	51 42	4 43
342	8	W	·9336	3 50	19 55	17 8	9 50	52 9	8 40
343	9	Th	·9364	3 49	19 56	18 18	10 40	52 35	12 36
344	10	F	·9391	3 48	19 57	rises	11 33	53 3	16 33
345	11	S	·9418	3 49	19 58	4 34	12 29	53 30	20 29
346	12	**S**	·9446	3 50	19 59	5 27	13 26	53 58	24 26
347	13	M	·9473	3 50	20 0	6 30	14 24	54 26	28 23
348	14	Tu	·9501	3 50	20 1	7 39	15 21	54 55	32 19
349	15	W	·9528	3 51	20 2	8 53	16 16	55 24	36 16
350	16	Th	·9555	3 51	20 3	10 9	17 10	55 53	40 12
351	17	F	·9583	3 52	20 4	11 27	18 2	56 22	44 9
352	18	S	·9610	3 52	20 4	12 43	18 52	56 52	48 5
353	19	**S**	·9637	3 52	20 5	13 57	19 43	57 22	52 2
354	20	M	·9665	3 53	20 6	15 12	20 34	57 51	55 58
355	21	Tu	·9692	3 53	20 6	16 27	21 26	58 21	17 59 55
356	22	W	·9720	3 54	20 7	17 37	22 18	58 51	18 3 52
357	23	Th	·9747	3 54	20 7	18 43	23 11	59 21	7 48
358	24	F	·9774	3 55	20 7	sets	......	23 59 52	11 45
359	25	S	·9802	3 55	20 8	4 27	0 4	0 0 22	15 41
360	26	**S**	·9829	3 56	20 8	5 22	0 56	0 51	19 38
361	27	M	·9856	3 56	20 8	6 21	1 46	1 21	23 34
362	28	Tu	·9884	3 56	20 8	7 23	2 35	1 51	27 31
363	29	W	·9911	3 56	20 8	8 25	3 21	2 20	31 27
364	30	Th	·9939	3 57	20 9	9 28	4 5	2 49	35 24
365	31	F	·9966	3 57	20 10	10 31	4 47	0 3 18	18 39 21

	d	h	m		d	h	m
First Quarter	3	2	25	**Full Moon**	10	21	30
Last Quarter	17	18	39	**New Moon**	24	21	55

Meteor Notes.

Moonlight interferes this year with the observation of the *Geminids*, the principal December shower, max. Dec. 10–11. The *Taurids* II., max. about Dec. 6, give a well-marked shower of slow meteors. Fireball dates:—**Dec. 2, 8, 11, 14, 19, 21, and 27.**

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
December	34	+28	Musca.	Dec. 13–Jan. ...	131	+48	ι Ursæ Major.
Dec. 6-12	80	+23	*Taurids* II.	Nov.–Dec.	145	+ 7	ο Leonis.
Dec. 6-13	82	+50	α Aurigæ.	Dec. 23	157	+64	α Ursæ Major.
Nov. 27–Dec. 27	105	+32	*Geminids.*	Dec. 22–Jan. ...	181	+35	Coma Ber.
Dec. 1-12	110	+24	δ Geminorum.	Dec.–Jan.	221	+41	β Boötis.
December	117	+32	α–β Geminorum	Dec. 4–8.........	280	+80	ε Ursæ Minor.

MERCURY (☿).

1886.		R.A.			Dec.			Diam.	Rises.		Transits.		Sets.	
		h	m	s	°	′		″	h	m	h	m	h	m
January	1	17	16	4	20	22	S.	7·7	18	18	22	30	2	42
	11	17	51	31	22	11		6·2	18	29	22	29	2	29
	21	18	46	51	23	12		5·4	18	52	22	46	2	40
	31	19	50	5	22	23		5·0	19	12	23	10	3	8
February	10	20	56	44	19	20		4·8	19	20	23	38	3	56
	20	22	5	6	13	58		4·8	19	10	0	4	4	58
March	2	23	14	36	6	18	S.	5·0	19	2	0	34	6	6
	12	0	21	47	2	45	N.	5·8	18	46	1	2	7	18
	22	1	11	18	10	11		7·6	18	15	1	12	8	9
April	1	1	22	32	12	15		10·0	17	35	0	43	7	51
	11	1	1	44	8	31		11·6	16	50	23	37	6	24
	21	0	48	4	4	12		10·8	16	21	22	46	5	11
May	1	1	1	33	3	40		9·0	16	3	22	23	4	43
	11	1	36	53	6	42		7·4	15	44	22	21	4	58
	21	2	28	45	12	1		6·2	15	29	22	35	5	41
	31	3	37	41	18	18		5·4	15	22	23	6	6	50
June	10	5	5	19	23	31		5·0	15	36	23	55	8	14
	20	6	39	50	24	57		5·2	16	14	0	45	9	16
	30	8	1	22	22	20		5·8	17	15	1	28	9	41
July	10	9	3	22	17	34		6·8	18	11	1	50	9	29
	20	9	45	41	12	23		8·0	18	44	1	53	9	2
	30	10	5	33	8	23		9·4	18	46	1	33	8	20
August	9	9	56	37	7	31		10·8	18	3	0	45	7	27
	19	9	27	47	10	46		10·4	16	32	23	31	6	30
	29	9	24	2	14	4		8·2	14	34	22	52	6	10
September	8	10	8	24	12	44		6·2	15	51	23	1	6	11
	18	11	15	53	6	44	N.	5·2	16	52	23	29	6	6
	28	12	22	27	1	0	S.	4·8	17	57	23	56	5	55
October	8	13	24	5	8	32		4·8	18	55	0	16	5	37
	18	14	23	3	15	8		4·8	19	51	0	35	5	19
	28	15	21	10	20	25		5·2	20	42	0	54	5	6
November	7	16	17	24	23	59		5·8	21	24	1	11	4	58
	17	17	2	55	25	18		7·2	21	40	1	17	4	54
	27	17	8	11	23	35		9·2	20	54	0	43	4	32
December	7	16	19	14	19	3		9·4	18	43	23	7	3	31
	17	16	12	40	18	29		7·4	18	5	22	27	3	51
	27	16	53	9	21	8	S.	6·0	18	24	22	31	2	38

At greatest elongation:—23° 21′ W., January $8^{\mathrm{d}}\ 14^{\mathrm{h}}$; 18° 31′ E., March $21^{\mathrm{d}}\ 14^{\mathrm{h}}$; 26° 16′ W., May $6^{\mathrm{d}}\ 13^{\mathrm{h}}$; 26° 52′ E., July $18^{\mathrm{d}}\ 22^{\mathrm{h}}$; 18° 5′ W., September $1^{\mathrm{d}}\ 23^{\mathrm{h}}$; 22° 29′ E., November $13^{\mathrm{d}}\ 5^{\mathrm{h}}$; 21° 52′ W., December $22^{\mathrm{d}}\ 2^{\mathrm{h}}$.

In superior conjunction:—February $24^{\mathrm{d}}\ 4^{\mathrm{h}}$; June $11^{\mathrm{d}}\ 14^{\mathrm{h}}$; September $27^{\mathrm{d}}\ 15^{\mathrm{h}}$.

In inferior conjunction:—April $8^{\mathrm{d}}\ 16^{\mathrm{h}}$; August $15^{\mathrm{d}}\ 20^{\mathrm{h}}$; December $3^{\mathrm{d}}\ 0^{\mathrm{h}}$.

Stationary:—March $29^{\mathrm{d}}\ 14^{\mathrm{h}}$; April $21^{\mathrm{d}}\ 2^{\mathrm{h}}$; August $1^{\mathrm{d}}\ 3^{\mathrm{h}}$; August $24^{\mathrm{d}}\ 23^{\mathrm{h}}$; November $23^{\mathrm{d}}\ 2^{\mathrm{h}}$; December $12^{\mathrm{d}}\ 18^{\mathrm{h}}$.

VENUS (♀).

1886.		R.A.	Dec.	Diam.	Rises.	Transits.	Sets.
		h m s	° ′	″	h m	h m	h m
January	1	21 52 59	13 13 S.	33·4	22 15	3 9	8 3
	11	22 16 49	9 24	38·6	21 39	2 53	8 7
	21	22 30 25	5 59	45·2	20 54	2 27	8 0
	31	22 30 36	3 31	52·6	20 2	1 48	7 34
February	10	22 16 6	2 39	58·8	19 3	0 54	6 45
	20	21 52 41	3 40	60·2	18 0	23 45	5 30
March	2	21 33 58	5 46	56·0	17 14	22 48	4 22
	12	21 29 46	7 41	48·8	16 41	22 6	3 31
	22	21 40 34	8 41	41·5	16 18	21 39	3 0
April	1	22 2 36	8 34	35·3	16 0	21 22	2 44
	11	22 31 54	7 25	30·5	15 47	21 13	2 39
	21	23 5 38	5 21	26·6	15 32	21 7	2 42
May	1	23 42 8	2 34 S.	23·7	15 15	21 5	2 55
	11	0 20 25	0 44 N.	21·2	15 0	21 4	3 8
	21	1 0 7	4 22	19·3	14 38	21 4	3 30
	31	1 41 12	8 8	17·7	14 21	21 6	3 51
June	10	2 23 50	11 50	16·3	14 5	21 9	4 13
	20	3 8 14	15 16	15·3	13 48	21 14	4 40
	30	3 54 36	18 14	14·3	14 38	21 21	4 4
July	10	4 42 56	20 32	13·5	13 33	21 31	5 29
	20	5 32 58	22 0	12·9	13 31	21 41	5 51
	30	6 24 13	22 30	12·3	13 40	21 53	6 6
August	9	7 15 55	21 57	11·8	13 56	22 5	6 14
	19	8 7 14	20 23	11·3	14 18	22 17	6 16
	29	8 57 35	17 49	11·0	14 48	22 28	6 8
September	8	9 46 33	14 25	10·8	15 17	22 38	5 59
	18	10 34 9	10 21	10·4	15 48	22 46	5 44
	28	11 20 39	5 46	10·2	16 21	22 53	5 25
October	8	12 6 30	0 54 N.	10·1	16 55	22 59	5 3
	18	12 52 20	4 3 S.	10·0	17 22	23 5	4 48
	28	13 38 49	8 54	9·8	17 52	23 13	4 34
November	7	14 26 33	13 25	9·8	18 27	23 21	4 16
	17	15 16 2	17 24	9·8	19 0	23 31	4 2
	27	16 7 32	20 35	9·8	19 32	23 44	3 56
December	7	17 0 53	22 49	9·8	20 4	23 58	3 52
	17	17 55 32	23 54	9·8	20 24	0 11	3 58
	27	18 50 35	23 45 S.	9·8	20 40	0 27	4 18

At greatest elongation:—46° 8′ W., April 29^{d} 5^{h}.
In superior conjunction:—December 2^{d} 17^{h}.
In inferior conjunction:—February 18^{d} 7^{h}.
Stationary:—January 26^{d} 4^{h}; March 9^{d} 14^{h}.
At greatest brilliancy:—March 25.

MARS (♂).

1886.		R.A.	Dec.	Diam.	Rises.	Transits.
		h m s	° ′	″	h m	h m
January	1	11 35 1	5 53 N.	10·6	10 16	16 49
	11	11 43 7	5 18	11·5	9 48	16 17
	21	11 47 34	5 7	12·5	9 14	15 42
	31	11 47 43	5 24	13·7	8 32	15 3
February	10	11 43 2	6 10	14·9	7 44	14 18
	20	11 33 35	7 20	15·8	6 48	13 29
March	2	11 20 24	8 45	16·4	5 48	12 37
	12	11 5 33	10 8	16·6	4 45	11 43
	22	10 51 48	11 13	16·0	3 47	10 50
April	1	10 41 25	11 50	15·2	2 55	10 0
	11	10 35 41	11 56	14·2	2 10	9 16
	21	10 34 51	11 34	13·2	1 31	8 36
May	1	10 38 26	10 47	12·2	0 59	8 0
	11	10 45 47	9 40	11·2	0 34	7 28
	21	10 56 13	8 15	10·4	0 13	6 59
	31	11 9 4	6 36	9·6	23 57	6 33
June	10	11 23 56	4 45	9·0	23 40	6 8
	20	11 40 26	2 44	8·6	23 29	5 45
	30	11 58 17	0 34 N.	8·0	23 19	5 24
July	10	12 17 22	1 42 S.	7·6	23 9	5 4
	20	12 37 33	4 4	7·4	23 1	4 44
	30	12 58 47	6 28	7·0	22 56	4 26
August	9	13 21 5	8 53 S.	6·8	22 49	4 9

JUPITER (♃).

January	1	12 22 4	0 57 S.	35·1	11 36	17 35
	21	12 24 16	1 6	37·3	10 20	16 18
February	10	12 21 49	0 44 S.	39·3	8 58	14 57
March	2	12 15 15	0 3 N.	40·8	7 30	13 32
	22	12 6 13	1 3	41·4	5 55	12 4
April	11	11 57 10	2 1	40·8	4 24	10 37
May	1	11 50 31	2 41	39·4	2 55	9 12
	21	11 47 49	2 54	37·4	1 32	7 50
June	10	11 49 29	2 38	35·2	0 16	6 33
	30	11 55 13	1 55	33·2	23 7	5 20
July	20	12 4 21	0 52 N.	31·6	22 3	4 11
December	20	13 55 29	10 34 S.	31·2	14 48	19 57
	30	14 1 13	11 4 S.	32·0	14 17	19 23

Mars.—Stationary, January 26^d 9^h; April 17^d 18^h. In opposition, M 6^d c^h. In quadrature, June 10^d 16^h.

Jupiter.—Stationary, January 20^d 11^h; May 23^d 8^h. In opposition, March 2 In quadrature, June 17^d 22^h. In conjunction with the Sun, October 9^d 5^h.

SATURN (♄).

1886.		R.A.			Dec.		Diam.	Rises		Transits		Sets	
		h	m	s	°	′	″	h	m	h	m	h	m
January	1	6	19	9	22	32 N.	18·6	3	22	11	33	19	44
	21	6	12	35	22	37	18·3	1	56	10	8	18	20
February	10	6	7	58	22	42	17·8	0	33	8	45	16	57
March	2	6	6	15	22	45	17·2	23	11	7	24	15	37
	22	6	7	45	22	49	16·6	21	53	6	7	14	21
April	11	6	12	17	22	51	16·0	20	39	4	53	13	7
September	18	7	28	58	21	33	15·8	11	33	19	37	3	41
October	8	7	34	23	21	22	16·4	10	20	18	23	2	26
	28	7	36	57	21	18	17·0	9	4	17	7	1	10
November	17	7	36	24	21	20	17·6	7	45	15	48	23	51
December	7	7	32	50	21	30	18·2	6	22	14	26	22	30
	27	7	26	57	21	45 N.	18·4	4	55	13	1	21	7

URANUS (♅).

February	10	12	28	5	2	13 S.	3·8	9	51	15	4	20	57
March	12	12	24	15	1	48	4·0	7	7	13	2	18	57
April	11	12	19	33	1	18	4·0	5	2	10	59	16	56
May	11	12	15	47	0	54	3·8	2	58	8	57	14	56
June	10	12	14	18	0	46	3·8	0	58	6	53	12	58
July	10	12	15	40	0	56	3·6	23	3	5	2	11	1
	20	12	16	44	1	3 S.	3·6	22	25	4	23	10	21

NEPTUNE (♆).

January	1	3	24	29	16	50 N.	1·3	1	4	8	39	16	14
	31	3	23	21	16	48	1·3	23	5	6	40	14	15
March	2	3	24	16	16	53	1·3	21	8	4	43	12	18
September	28	3	43	6	17	56	1·3	7	31	15	12	22	53
October	28	3	40	33	17	47	1·3	5	30	13	11	20	52
November	27	3	37	10	17	35	1·3	3	30	11	10	18	50
December	27	3	34	8	17	26 N.	1·3	1	30	9	9	16	48

Saturn.—Stationary, March 2ᵈ 17ʰ; November 3ᵈ 11ʰ. In quadrature, March 21ᵈ 23ʰ. In conjunction, July 3ᵈ 14ʰ. In quadrature, October 15ᵈ 3ʰ.

Uranus.—Stationary, January 11ᵈ 16ʰ; June 10ᵈ 18ʰ. In opposition, March 25ᵈ 22ʰ. In quadrature, June 24ᵈ 20ʰ. In conjunction, September 30ᵈ 22ʰ.

Neptune.—Stationary, February 1ᵈ 21ʰ; August 31ᵈ 7ʰ. In quadrature, February 11ᵈ 1ʰ. In conjunction, May 15ᵈ 18ʰ. In quadrature, August 20ᵈ 12ʰ. In opposition, November 18ᵈ 7ʰ.

OCCULTATIONS, 1886.

(VISIBLE AT GREENWICH.)

Date.	Star.	Mag.	Disap.	Angle.	Reap.
Jan.			h m	°	h m
14	B.A.C. 830......	6	7 9	73	8 11
16	θ^1 Tauri	4½	3 56	106	4 58
16	θ^2 Tauri	4½	3 58	86	4 56
16	B.A.C. 1391 ...	5	4 58	131	5 57
16	Aldebaran	1	7 48	137	8 49
17	117 Tauri	6	3 38	73	4 28
17	130 Tauri	6	12 54	88	13 59
18	26 Geminorum ..	5½	8 37	73	9 44
19	1 Cancri	6	14 3	32	14 49
22	37 Sextantis	6	7 16‡	69	8 7
23	B.A.C. 4043	6½	15 40	100	16 40
Feb.					
10	B.A.C. 741......	6½	6 6	141	7 12
12	48 Tauri........	6	8 40	66	9 40
12	γ Tauri	4	10 45	89	11 47
12	71 Tauri........	6	13 43	58	14 25‡
13	111 Tauri	5½	13 51	124	14 34
13	117 Tauri	6	15 10	95	15 59‡
17	ξ Leonis	6	14 19	63	15 21
18	48 Leonis	6	15 44	54	16 43
19	τ Leonis	5	13 5	27	14 0
20	13 Virginis......	6	9 36	109	10 23
20	URANUS	—	17 53	19	18 34
22	κ Virginis	4½	13 3	352	13 20
Mar.					
9	64 Ceti	6	5 31	89	6 38
9	ξ^1 Ceti	4½	6 35	120	7 39
13	130 Tauri	6	4 49	114	6 1
13	B.A.C. 1930	6½	12 40	112	13 28
15	1 Cancri........	6	10 15	43	11 12
18	37 Sextantis	6	5 25	50	6 17
19	B.A.C. 4043	6½	13 38	101	14 34
23	γ Libræ	4½	11 19	126	11 58
23	η Libræ	6	16 18	68	17 34
Apr.					
8	Aldebaran	1	5 8	149	5 54
9	130 Tauri	6	11 49	139	12 21‡

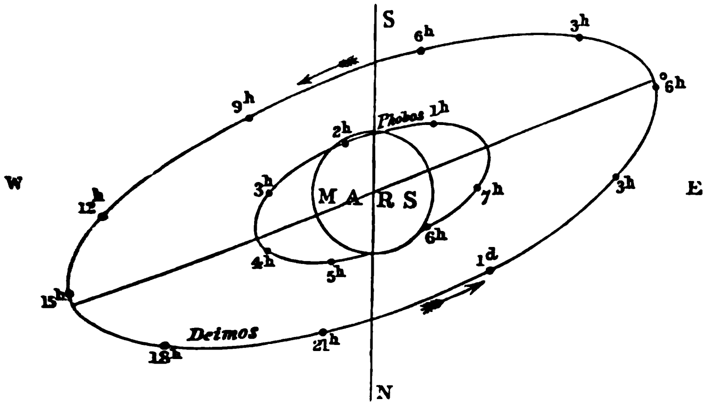
te.	Star.	Mag.	Disap.	Angle.	Reap.	Angle.
pr.			h m	°	h m	°
10	26 Geminorum ..	5½	10 25	101	11 18	245
14	48 Leonis	6	10 57	16	11 40	299
15	τ Leonis	5	9 21	4	9 55	308
16	13 Virginis	6	6 14	105	7 4	212
16	URANUS	—	9 58	14	10 44	296
18	κ Virginis	4½	9 5	18	9 48	297
27	e^1 Aquarii	6	15 38	76	16 42	315
28	78 Aquarii	6	14 49‡	178	15 8	213
lay						
6	111 Tauri	5½	8 12	74	9 3	286
6	117 Tauri	6	9 42	52	10 21‡	308
14	θ Virginis	4½	14 42	55	15 36‡	270
17	η Libræ	6	10 16	80	11 32	244
21	*d* Sagittarii......	5	10 1‡	57	10 57	300
une						
9	B.A.C. 4043	6½	12 5	35	12 51*	286
17	B.A.C. 6536	6½	14 59	68	16 7	309
19	B.A.C. 7145	6½	9 40‡	150	10 18	221
20	B.A.C. 7487	6½	12 36	116	13 55	274
23	24 Piscium	6½	12 43	124	13 47	275
uly						
16	B.A.C. 7097	6	15 44	104	16 55	289
24	μ Ceti	4	11 32§	89	12 24	306
26	85 Tauri........	6	12 4‡	123	12 49	260
26	σ^2 Tauri	5	15 6	51	15 43	337
ug.						
5	95 Virginis......	6	9 54	71	10 53‡	258
8	24 Scorpii	5	7 15	94	8 34	244
11	*d* Sagittarii......	5	6 44	101	8 0	259
17	5 Ceti	6	10 3	45	10 32	356
17	B.A.C. 5........	6	10 11	97	11 21	306
19	ν Piscium	4½	10 42	106	11 47	296
22	48 Tauri........	6	13 23	166	13 54	226
22	γ Tauri	4	15 22	151	16 13	241
ept.						
3	γ Libræ	4½	9 19	107	10 13‡	234
7	B.A.C. 6536	6½	9 43	47	10 33	329
10	B.A.C. 7487	6½	8 11	148	9 12	244
20	130 Tauri	6	11 34	108	12 30	270
21	26 Geminorum ..	5½	10 46‡	57	11 26	310
24	B.A.C. 3345	6	13 53‡	96	14 41	244
ct.						
6	B.A.C. 7097	6	10 33	115	11 42	278
12	*f* Piscium	5½	11 58	38	12 15	13

Date.	Star.	Mag.	Disap.	Angle.	Reap.
Oct.			h m	°	h m
14	μ Ceti	4	6 11§	84	7 1
16	θ^2 Tauri	4½	6 52‡	132	7 36
16	θ^1 Tauri	4½	7 1‡	162	7 27
16	80 Tauri........	6	7 25	61	8 4
16	81 Tauri........	5½	7 36	68	8 20
16	85 Tauri........	6	8 5	92	8 59
17	111 Tauri	5½	7 24‡	101	8 14
17	117 Tauri	6	9 9	18	9 17
22	B.A.C. 3538	6½	12 53‡	24	13 23
22	44 Leonis	6	14 6	23	14 38
22	B.A.C. 3562	6½	14 14	26	14 49
Nov.					
3	B.A.C. 7263	6	3 16	81	4 32
7	4 Ceti	6	5 45	61	6 32
7	5 Ceti	6	6 0	77	7 1
7	B.A.C. 5........	6	6 23	115	7 42
9	ν Piscium	4½	6 4	96	7 9
12	48 Tauri........	6	7 18	101	8 18
12	γ Tauri	4	9 17	92	10 25
12	75 Tauri........	6	14 38	138	15 37
12	θ^1 Tauri	4½	14 46	36	15 57
12	B.A.C. 1391	5	15 39	82	16 46
12	Aldebaran	1	18 27	124	19 16
13	115 Tauri	6	16 2	108	17 11
21	46 Virginis......	6	16 42	107	17 31
21	48 Virginis......	6	18 36	127	19 8
22	B.A.C. 4647	6	16 42	61	17 40
Dec.					
3	h^1 Aquarii	5½	5 8	127	6 30
9	48 Tauri........	6	17 52	68	18 38‡
10	B.A.C. 1526	6	10 29	95	11 44
13	3 Cancri	6	13 42	112	14 46
14	54 Cancri	6½	9 26	126	10 9
18	γ^1 Virginis	2½	13 50	112	14 34
18	B.A.C. 4277	6	14 55	134	15 21
28	29 Capricorni....	6	6 31	127	7 34‡

‡ Star below the horizon. * Star setting. § Star risi

The angles are reckoned from the *apparent* N. point towards the righ the Moon's inverted image.

SATELLITES OF MARS.



The circle represents the disk of the planet, and is on the same scale as the orbits.

PHOBOS.

Greenwich Mean Times of East Elongations visible at Greenwich.

February.		February.		February.		March.		March.		March.	
d	h	d	h	d	h	d	h	d	h	d	h
11	13·45	19	12·74	26	13·06	5	13·39	13	12·68	22	10·92
12	12·41	20	11·69	27	12·01	6	12·34	14	11·63	23	9·88
13	11·37	21	10·65	28	10·96	7	11·30	15	10·59	24	16·48
14	17·98	22	17·25	March.		8	10·26	16	9·55		8·83
	10·33		9·60	1	9·92	9	16·86	17	16·15	25	15·43
15	16·94	23	16·21	2	16·52		9·21		8·50		7·78
	9·29		8·55		8·87	10	15·82	18	15·11	26	14·39
16	15·89	24	15·16	3	15·48		8·17		7·46	27	13·34
	8·24	25	14·11		7·83	11	14·77	19	14·06	28	12·30
17	14·84			4	14·43		7·12	20	13·01		
18	13·79				6·78	12	13·73	21	11·97		

DEIMOS.

Greenwich Mean Times of every East Elongation.

February.		February.		February.		March.		March.		March.	
d	h	d	h	d	h	d	h	d	h	d	h
10	16·93	19	12·73	28	8·52	7	22·07	16	17·85	25	13·64
11	23·19	20	19·00	March.		9	4·31	18	0·12	26	19·90
13	5·45	22	1·24	1	14·78	10	10·57	19	6·37	28	2·17
14	11·70	23	7·50	2	21·04	11	16·82	20	12·62	29	8·42
15	17·96	24	13·75	4	3·28	12	23·09	21	18·88	30	14·67
17	0·22	25	20·02	5	9·54	14	5·34	23	1·15	31	20·93
18	6·47	27	2·26	6	15·80	15	11·60	24	7·39		

The times of the West Elongations may be found from the times of the East Elongations by adding or subtracting $3^{h}\cdot83$ for Phobos and $15^{h}\cdot13$ for Deimos.

The position-angle and distance of Deimos when at East Elongation are as follows:—Feb. 10, $16^{h}\cdot93$, $111^{\circ}\cdot4$, $45''\cdot5$; Mar. 15, $11^{h}\cdot60$, $105^{\circ}\cdot3$, $49''\cdot9$; Mar. 31. $20^{h}\cdot93$, $102^{\circ}\cdot5$, $46''\cdot4$.

ECLIPSES OF JUPITER'S SATELLITES, 1886.

January.

d	h	m	
2	2	35	i. D.
3	10	36	iv. D.
	13	13	iv. R.
	13	29	ii. D.
	21	3	i. D.
4	18	29	iii. D.
	21	28	iii. R.
5	15	31	i. D.
7	2	46	ii. D.
	10	0	i. D.
9	4	28	i. D.
10	16	4	ii. D.
	22	56	i. D.
11	22	26	iii. D.
12	1	24	iii. R.
	17	24	i. D.
14	5	21	ii. D.
	11	53	i. D.
16	6	21	i. D.
17	18	39	ii. D.
18	0	49	i. D.
19	2	23	iii. D.
	5	20	iii. R.
	19	17	i. D.
20	4	37	iv. D.
	7	2	iv. R.
21	7	56	ii. D.
	13	46	i. D.
23	8	14	i. D.
24	21	14	ii. D.
25	2	42	i. D.
26	6	21	iii. D.
	9	17	iii. R.
	21	10	i. D.
28	10	32	ii. D.
	15	39	i. D.
30	10	7	i. D.
31	23	50	ii. D.

February.

1	4	35	i. D.
2	10	19	iii. D.
	13	14	iii. R.
	23	3	i. D.
4	13	7	ii. D.
	17	32	i. D.
5	22	38	iv. D.
6	0	51	iv. R.
	12	0	i. D.

February (con.).

d	h	m	
8	2	6	ii. D.
	6	28	i. D.
9	14	17	iii. D.
	17	11	iii. R.
10	0	57	i. D.
11	15	43	ii. D.
	19	25	i. D.
13	13	53	i. D.
15	5	1	ii. D.
	8	21	i. D.
16	18	15	iii. D.
	21	8	iii. R.
17	2	50	i. D.
18	18	19	ii. D.
	21	18	i. D.
20	15	46	i. D.
22	7	37	ii. D.
	10	15	i. D.
	16	40	iv. D.
	18	40	iv. R.
23	22	13	iii. D.
24	4	43	i. D.
25	20	55	ii. D.
	23	11	i. D.
27	17	40	i. D.

March.

1	10	14	ii. D.
	12	8	i. D.
3	2	10	iii. D.
	6	36	i. D.
4	23	31	ii. D.
5	1	5	i. D.
6	19	33	i. D.
8	12	50	ii. D.
	14	1	i. D.
10	6	8	iii. D.
	8	30	i. D.
11	10	45	iv. D.
11	12	28	iv. R.
12	2	8	ii. D.
	2	58	i. D.
13	21	27	i. D.
15	15	27	ii. D.
	15	55	i. D.
17	10	6	iii. D.
	10	23	i. D.
19	4	44	ii. D.
	4	52	i. D.

March (con.).

d	h	m	
22	20	0	i. R.
	20	48	ii. R.
24	14	28	i. R.
	16	53	iii. R.
26	8	57	i. R.
	10	6	ii. R.
28	3	25	i. R.
	4	50	iv. D.
	6	15	iv. R.
29	21	53	i. R.
	23	25	ii. R.
31	16	22	i. R.
	20	50	iii. R.

April.

2	10	50	i. R.
	12	42	ii. R.
4	5	19	i. R.
5	23	47	i. R.
6	2	1	ii. R.
7	18	16	i. R.
8	0	48	iii. R.
9	12	44	i. R.
	15	19	ii. R.
11	7	13	i. R.
13	1	41	i. R.
	4	38	ii. R.
	22	59	iv. D.
14	0	1	iv. R.
	20	10	i. R.
15	4	46	iii. R.
16	14	38	i. R.
	17	56	ii. R.
18	9	7	i. R.
20	3	35	i. R.
	7	15	ii. R.
21	22	4	i. R.
22	6	0	iii. D.
	8	43	iii. R.
23	16	33	i. R.
	20	33	ii. R.
25	11	1	i. R.
27	5	30	i. R.
	9	52	ii. R.
28	23	58	i. R.
29	9	59	iii. D.
	12	41	iii. R.
30	17	20	iv. D.
	17	37	iv. R.

April (co

d	h	m	
30	18	27	i.
	23	9	ii.

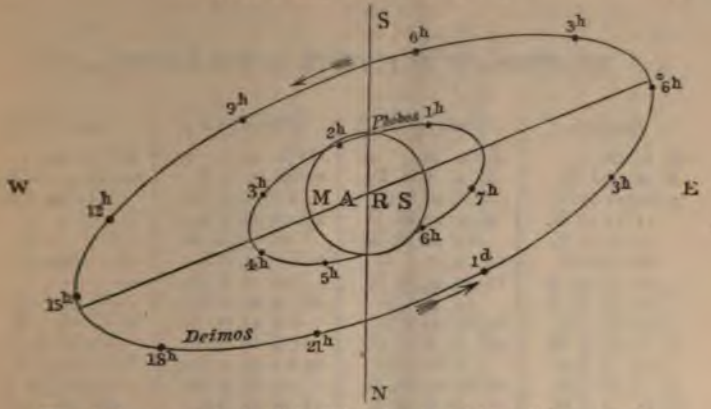
May.

2	12	55	i.
4	7	24	i.
	12	28	ii.
6	1	53	i.
	13	57	iii.
	16	39	iii.
7	20	21	i.
8	1	46	ii.
9	14	50	i.
11	9	18	i.
	15	5	ii.
13	3	47	i.
	17	57	iii.
	20	37	iii.
14	22	16	i.
15	4	23	ii.
16	16	44	i.
18	11	13	i.
	17	42	ii.
20	5	42	i.
	21	56	iii.
21	0	35	iii.
22	0	10	i.
	7	0	ii.
23	18	39	i.
25	13	8	i. R
	20	18	ii.
27	7	36	i. R
28	1	56	iii.
	4	34	iii.
29	2	5	i. R
	9	36	ii.
30	20	34	i. R

June.

1	15	2	i. R
	22	55	ii.
3	9	31	i. R
4	5	55	iii.
	8	32	iii.
5	4	0	i. R.
	12	13	ii. R
6	22	28	i. R.

SATELLITES OF MARS.



The circle represents the disk of the planet, and is on the same scale as the orbits.

PHOBOS.

Greenwich Mean Times of East Elongations visible at Greenwich.

February.		February.		February.		March.		March.		March.	
d	h	d	h	d	h	d	h	d	h	d	h
11	13·45	19	12·74	26	13·06	5	13·39	13	12·68	22	10·92
12	12·41	20	11·69	27	12·01	6	12·34	14	11·63	23	9·88
13	11·37	21	10·65	28	10·96	7	11·30	15	10·59	24	16·48
14	17·98	22	17·25	March.		8	10·26	16	9·55		8·83
	10·33		9·60	1	9·92	9	16·86	17	16·15	25	15·43
15	16·94	23	16·21	2	16·52		9·21		8·50		7·78
	9·29		8·55		8·87	10	15·82	18	15·11	26	14·39
16	15·89	24	15·16	3	15·48		8·17		7·46	27	13·34
	8·24	25	14·11		7·83	11	14·77	19	14·06	28	12·30
17	14·84			4	14·43		7·12	20	13·01		
18	13·79				6·78	12	13·73	21	11·97		

DEIMOS.

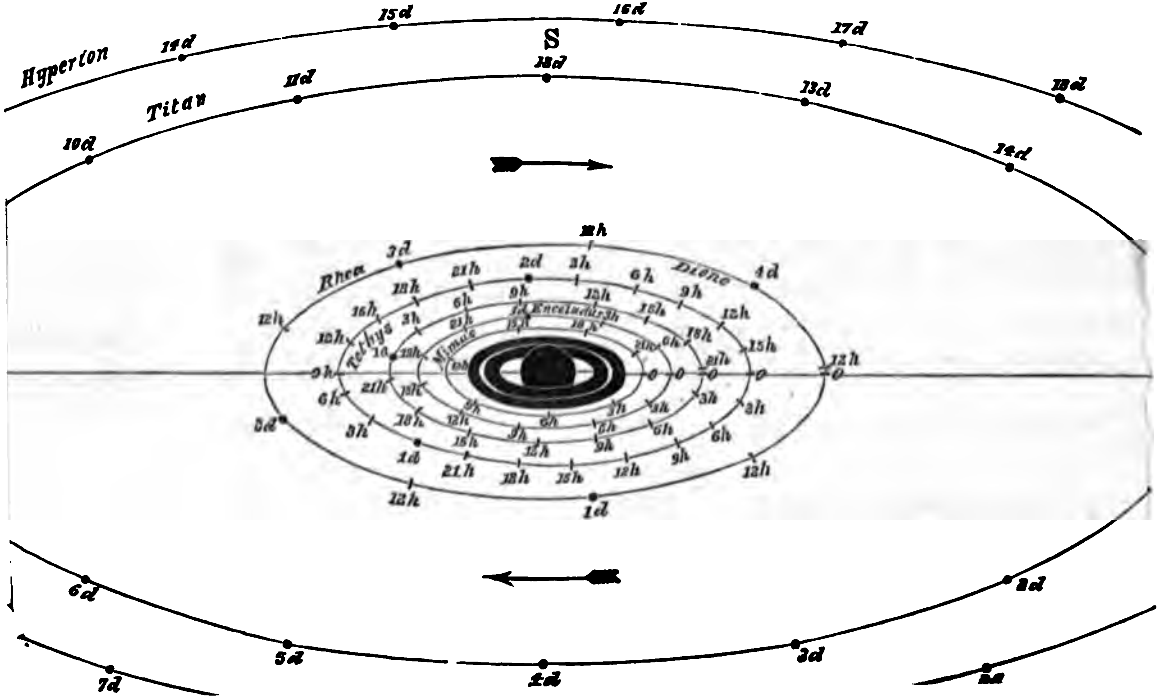
Greenwich Mean Times of every East Elongation.

February.		February.		February.		March.		March.		March.	
d	h	d	h	d	h	d	h	d	h	d	h
10	16·93	19	12·73	28	8·52	7	22·07	16	17·85	25	13·64
11	23·19	20	19·00	March.		9	4·31	18	0·12	26	19·90
13	5·45	22	1·24	1	14·78	10	10·57	19	6·37	28	2·17
14	11·70	23	7·50	2	21·04	11	16·82	20	12·62	29	8·42
15	17·96	24	13·75	4	3·28	12	23·09	21	18·88	30	14·67
17	0·22	25	20·02	5	9·54	14	5·34	23	1·15	31	20·93
18	6·47	27	2·26	6	15·80	15	11·60	24	7·39		

The times of the West Elongations may be found from the times of the East Elongations by adding or subtracting $3^{h}\cdot83$ for Phobos and $15^{h}\cdot13$ for Deimos.

The position-angle and distance of Deimos when at East Elongation are as follows:—Feb. 10, $16^{h}\cdot93$, $111^{\circ}\cdot4$, $45''\cdot5$; Mar. 15, $11^{h}\cdot60$, $105^{\circ}\cdot3$, $49''\cdot9$; Mar. 31, $20^{h}\cdot93$, $102^{\circ}\cdot5$, $46''\cdot4$.

ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, as seen in an Inverting T



SATELLITES OF SATURN.

Greenwich Mean Times of East Elongations.

MIMAS.

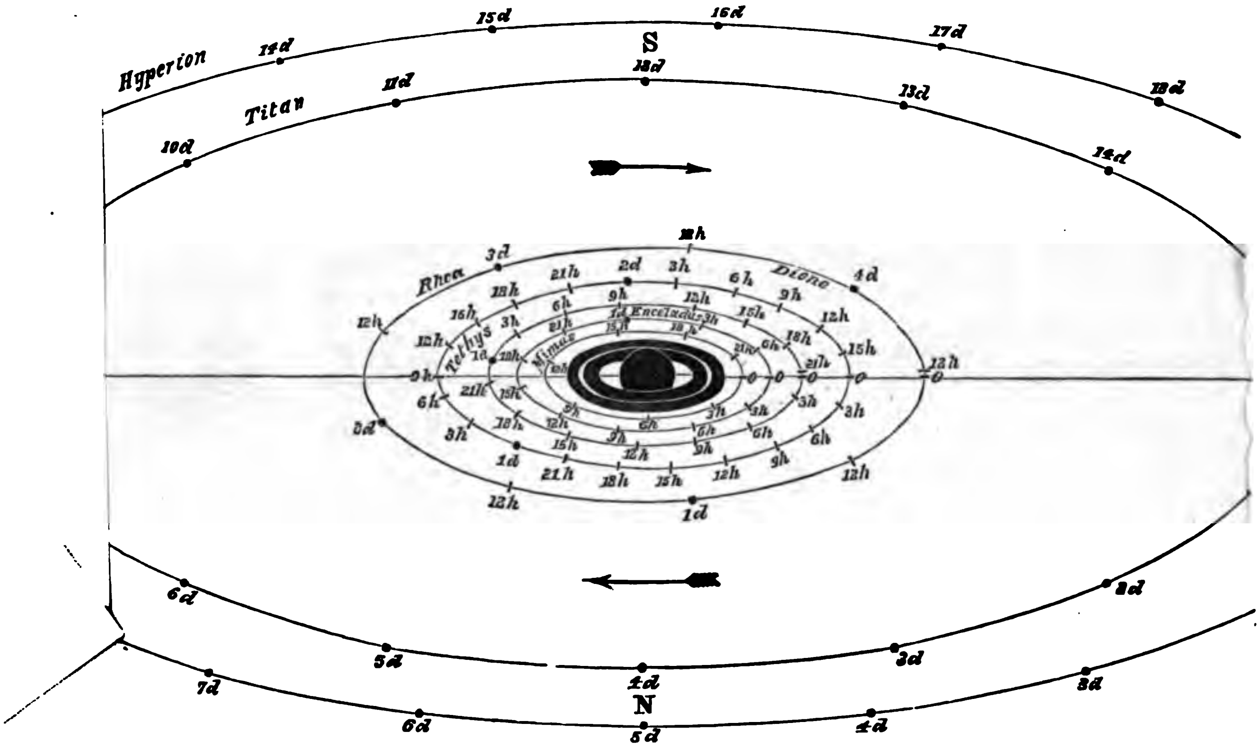
Note.—In the case of Mimas, which can usually be only seen at elongation, the times of those elongations, both East and West, which are visible at Greenwich are given.

January.	February.	March.	April.	October.	November.	December.
d h	d h	d h	d h	d h	d h	d h
1 16·0 E.	1 8·3 W.	1 14·8 W.	4 13·1 W.	1 14·8 W.	1 17·2 W.	1 9·7 E.
3 14·6 E.	2 6·9 W.	2 13·4 W.	5 11·7 W.	2 13·4 W.	2 15·8 W.	2 8·3 E.
4 13·3 E.	4 15·4 E.	3 12·0 W.	6 10·3 W.	3 12·0 W.	3 14·4 W.	5 15·5 W.
5 11·9 E.	5 14·0 E.	4 10·6 W.	7 8·9 W.	7 17·7 E.	4 13·0 W.	6 14·1 W.
6 10·5 E.	6 12·6 E.	5 9·3 W.	8 7·6 W.	8 16·3 E.	5 11·7 W.	7 12·7 W.
7 9·1 E.	7 11·2 E.	6 7·9 W.	12 13·4 E.	9 14·9 E.	6 10·3 W.	15 13·0 E.
8 7·7 E.	8 9·8 E.	10 13·7 E.	13 12·0 E.	10 13·5 E.	7 8·9 W.	16 11·6 E.
10 16·2 W.	9 8·4 E.	11 12·3 E.	14 10·6 E.	16 16·6 W.	14 10·5 E.	17 10·2 E.
11 14·8 W.	10 7·0 E.	12 10·9 E.	15 9·2 E.	17 15·2 W.	15 9·1 E.	18 8·8 E.
12 13·4 W.	21 14·5 E.	14 8·1 E.	21 12·4 W.	18 13·8 W.	18 16·3 W.	19 7·4 E.
13 12·0 W.	22 13·2 E.	22 8·4 W.	22 11·0 W.	19 12·4 W.	19 14·9 W.	21 16·0 W.
14 10·6 W.	23 11·8 E.	23 7·0 W.	23 9·6 W.	24 16·9 E.	20 13·5 W.	22 14·7 W.
15 9·2 W.	24 10·4 E.	27 12·8 E.	24 8·2 W.	25 15·5 E.	21 12·2 W.	23 13·3 W.
23 9·4 E.	25 9·1 E.	28 11·4 E.	30 11·2 E.	26 14·1 E.	22 10·8 W.	24 11·9 W.
24 8·0 E.	26 7·7 E.	29 10·0 E.		27 12·7 E.	23 9·4 W.	25 10·5 W.
27 15·2 W.		30 8·6 E.		28 11·3 E.	26 16·5 E.	26 9·1 W.
28 13·8 W.		31 7·2 E.		29 10·0 E.	27 15·2 E.	27 7·7 W.
29 12·5 W.				30 8·6 E.	28 13·8 E.	29 16·1 E.
30 11·1 W.					29 12·5 E.	30 14·7 E.
31 9·7 W.					30 11·1 E.	31 13·3 E.

ENCELADUS.

January.	February.	March.	April.	October.	November.	December.
d h	d h	d h	d h	d h	d h	d h
2 3·5	1 7·0	2 1·5	1 5·1	1 21·8	1 1·2	1 4·7
3 12·4	2 15·9	3 10·4	2 14·0	3 6·7	2 10·1	2 13·6
4 21·3	4 0·8	4 19·3	3 22·9	4 15·5	3 19·0	3 22·5
6 6·2	5 9·7	6 4·2	5 7·7	6 0·4	5 3·9	5 7·3
7 15·1	6 18·5	7 13·0	6 16·6	7 9·3	6 12·8	6 16·2
9 0·0	8 3·4	8 21·9	8 1·5	8 18·1	7 21·7	8 1·0
10 8·9	9 12·2	10 6·8	9 10·4	10 3·0	9 6·6	9 9·9
11 17·8	10 21·1	11 15·7	10 19·3	11 11·9	10 15·4	10 18·8
13 2·7	12 6·0	13 0·6	12 4·2	12 20·8	12 0·3	12 3·7
14 11·6	13 14·9	14 9·5	13 13·1	14 5·6	13 9·2	13 12·6
15 20·5	14 23·8	15 18·4	14 22·0	15 14·5	14 18·1	14 21·4
17 5·3	16 8·7	17 3·3	16 6·9	16 23·4	16 3·0	16 6·3
18 14·2	17 17·6	18 12·2	17 15·8	18 8·3	17 11·9	17 15·2
19 23·1	19 2·5	19 21·1	19 0·7	19 17·2	18 20·8	19 0·1
21 8·0	20 11·4	21 6·0	20 9·6	21 2·1	20 5·7	20 9·0
22 16·8	21 20·3	22 14·8	21 18·5	22 11·0	21 14·6	21 17·8
24 1·7	23 5·1	23 23·7	23 3·4	23 19·9	22 23·5	23 2·7
25 10·6	24 14·0	25 8·6	24 12·3	25 4·8	24 8·3	24 11·6
26 19·5	25 22·9	26 17·5	25 21·2	26 13·7	25 17·2	25 20·5
28 4·4	27 7·7	28 2·4	27 6·1	27 22·5	27 2·1	27 5·4
29 13·2	28 16·6	29 11·3	28 15·0	29 7·4	28 11·0	28 14·2
30 22·1		30 20·2	29 23·9	30 16·3	29 19·9	29 23·1

ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, as seen in an Inverting T



The arrows in the diagram show the direction of the motion of the Satellites. The figures indicate the interval from the time of last East elon

Greenwich Mean Times of East Elongations.

TITAN.

January.	February.	March.	April.	October.	November.	December,
d h	d h	d h	d h	d h	d h	d h
6 17·1	7 14·1	11 10·1	12 9·6	5 16·6	6 15·6	8 11·5
22 15·8	23 12·1	27 9·6	28 10·0	21 16·6	22 13·8	24 9·6

HYPERION.

January.	February.	March.	April.	October.	November.	December.
d h	d h	d h	d h	d h	d h	d h
8 10·1	19 23·1	13 4·6	3 13·1	13 8·9	3 16·8	16 4·1
29 17·7			24 21·6		24 22·3	

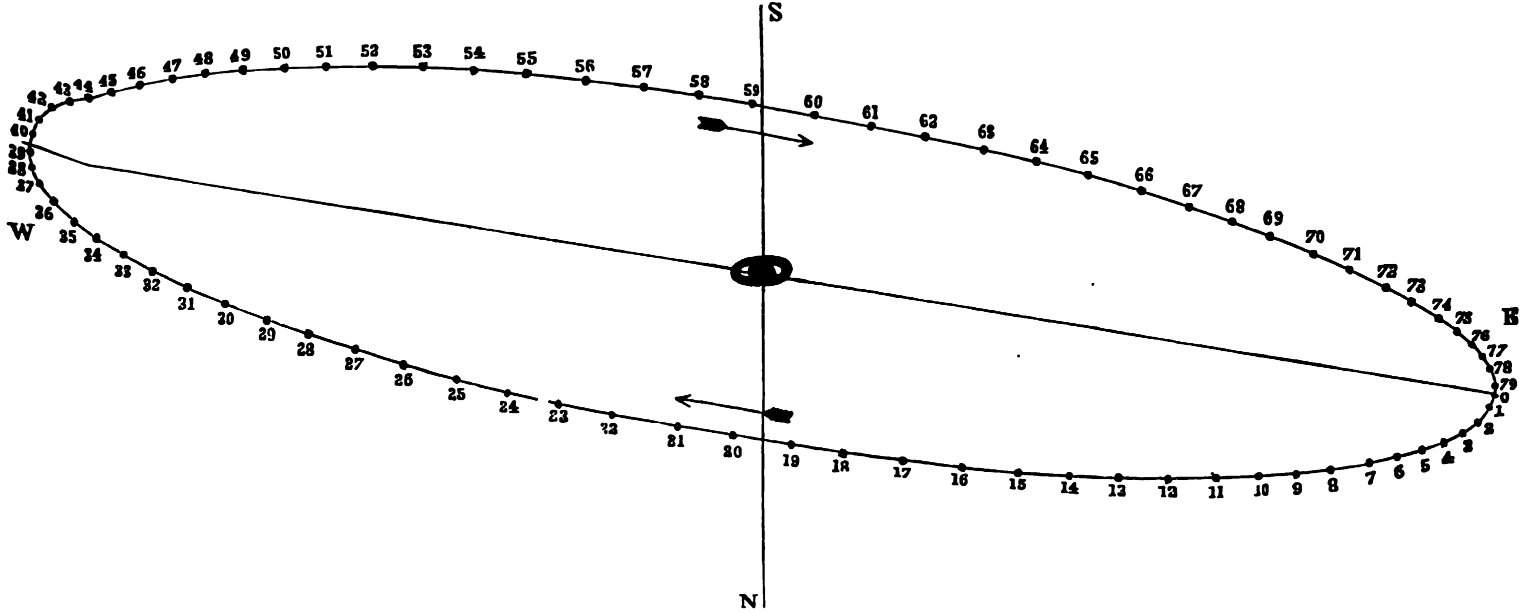
Apparent Elements of Saturn's Rings.

Greenwich Mean Noon.	Position-angle of Minor Axis.	Outer Ring.		Inner Ring.	
		Maj. Axis.	Min. Axis.	Maj. Axis.	Min. Axis.
	° ′	″	″	″	″
Jan. 3	353 22·0	46·58	20·51	30·98	13·64
23	353 28·3	45·94	20·41	30·55	13·57
Feb. 12	353 32·7	44·74	20·00	29·75	13·30
Mar. 4	353 34·0	43·23	19·39	28·74	12·90
24	353 31·9	41·65	18·69	27·70	12·43
April 13	353 26·9	40·20	17·98	26·73	11·95
May 3	353 19·2	39·00	17·32	25·93	11·52
Sept. 20	352 36·0	39·96	15·66	26·57	10·42
Oct. 10	352 34·7	41·37	16·00	27·51	10·64
30	352 34·2	42·92	16·51	28·54	10·98
Nov. 19	352 34·3	44·44	17·16	29·55	11·41
Dec. 9	352 35·0	45·69	17·85	30·39	11·87
29	352 36·6	46·42	18·45	30·87	12·27

Greenwich Mean Noon.	Latitude above Plane of Ring.		Semi-major Axis of Orbit.	
	Earth.	Sun.	Titan.	Iapetus.
	° ′	° ′	″	″
Jan. 3	26 7·3 S.	26 4·1 S.	209·5	609·7
23	26 22·5 S.	25 58·7 S.	206·6	601·2
Feb. 12	26 33·6 S.	25 53·3 S.	201·3	585·5
Mar. 4	26 39·5 S.	25 47·4 S.	194·5	565·8
24	26 39·7 S.	25 41·2 S.	187·4	545·2
Apr. 13	26 33·9 S.	25 34·9 S.	180·9	526·0
May 3	26 22·1 S.	25 28·2 S.	175·9	510·4
Sept. 20	23 4·7 S.	24 34·2 S.	179·8	523·0
Oct. 10	22 45·4 S.	24 25·5 S.	186·1	541·4
30	22 37·5 S.	24 16·5 S.	193·1	561·8
Nov. 19	22 42·6 S.	24 7·2 S.	199·9	581·7
Dec. 9	22 59·9 S.	23 57·7 S.	205·6	598·0
29	23 25·4 S.	23 47·9 S.	208·8	607·6

The semi-major axes of the orbits of Titan and Iapetus are given, as well as the position-angle of the minor axis of the ring, in order to furnish means for roughly inferring the distances and position-angles of the satellites from the diagrams given on p. 24 and p. 28.

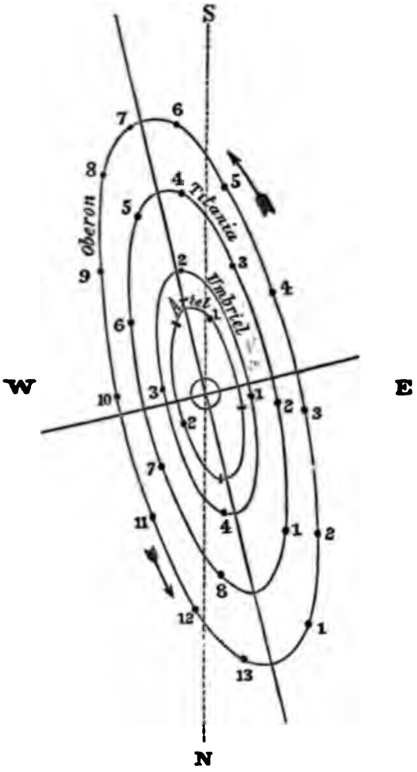
APPARENT ORBIT OF IAPETUS AS SEEN IN AN INVERTING TELESCOPE.



The arrows in the diagram show the direction of motion. The figures indicate the number of days from the time of the last East Elongation.

Dates of East Elongations of Iapetus :—

SATELLITES OF URANUS.



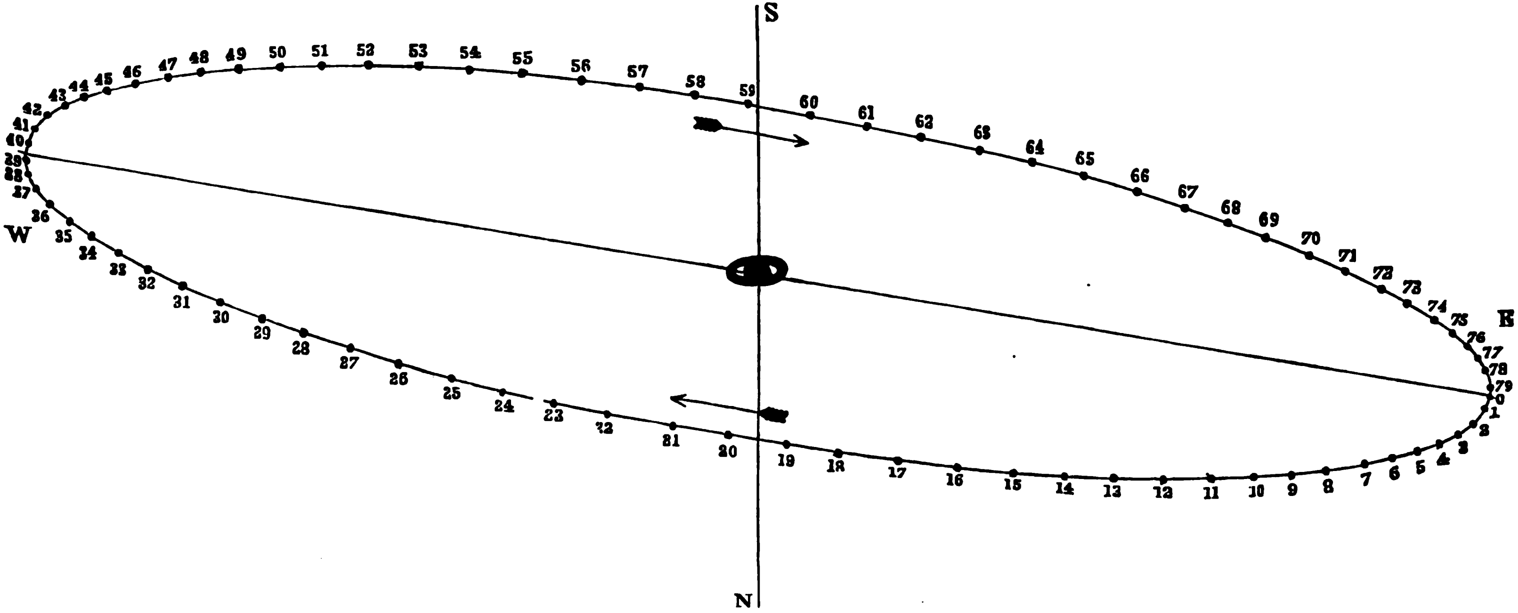
The small circle in the above diagram represents the planet, and is on the same scale as the orbits.

Greenwich Mean Times of North Elongations.

Ariel.

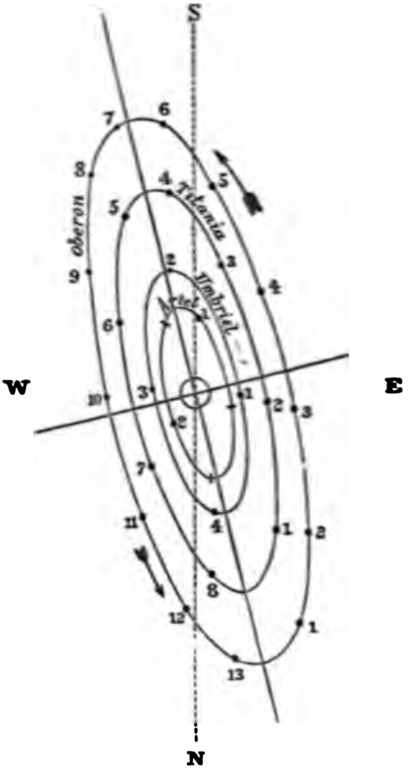
January.		February.		March.		April.		May.		June.	
d	h	d	h	d	h	d	h	d	h	d	h
3	4·6	2	10·5	2	3·9	1	9·8	1	15·7	3	10·2
5	17·2	4	23·0	4	16·4	3	22·3	4	4·2	5	22·7
8	5·6	7	11·5	7	4·9	6	10·8	6	16·7	8	11·2
10	18·2	10	0·0	9	17·4	8	23·3	9	5·2	10	23·7
13	6·6	12	12·5	12	5·8	11	11·8	11	17·7	13	12·2
15	19·2	15	1·0	14	18·3	14	0·2	14	6·2		
18	7·6	17	13·4	17	6·8	16	12·7	16	18·7		
20	20·1	20	1·9	19	19·3	19	1·2	19	7·2		
23	8·5	22	14·4	22	7·8	21	13·7	21	19·7		
25	21·1	25	2·9	24	20·3	24	2·2	24	8·2		
28	9·5	27	15·4	27	8·8	26	14·7	26	20·7		
30	22·0			29	21·3	29	3·2	29	9·2		
								31	21·7		

APPARENT ORBIT OF IAPETUS AS SEEN IN AN INVERTING TELESCOPE.



The arrows in the diagram show the direction of motion. The figures indicate the number of days from the time of the last East Elongation.
Dates of East Elongations of Iapetus:—1885, Dec. 13; 1886, March 3, May 23, August 13, November 1.

SATELLITES OF URANUS.



The small circle in the above diagram represents the planet, and is on the same scale as the orbits.

Greenwich Mean Times of North Elongations.

Ariel.

January.		February.		March.		April.		May.		June.	
d	h	d	h	d	h	d	h	d	h	d	h
3	4·6	2	10·5	2	3·9	1	9·8	1	15·7	3	10·2
5	17·2	4	23·0	4	16·4	3	22·3	4	4·2	5	22·7
8	5·6	7	11·5	7	4·9	6	10 8	6	16·7	8	11·2
10	18·2	10	0·0	9	17·4	8	23·3	9	5·2	10	23·7
13	6·6	12	12·5	12	5·8	11	11·8	11	17·7	13	12·2
15	19·2	15	1·0	14	18·3	14	0·2	14	6·2		
18	7·6	17	13·4	17	6·8	16	12·7	16	18·7		
20	20·1	20	1·9	19	19·3	19	1·2	19	7·2		
23	8·5	22	14·4	22	7·8	21	13·7	21	19·7		
25	21·1	25	2·9	24	20·3	24	2·2	24	8·2		
28	9·5	27	15·4	27	8·8	26	14·7	26	20·7		
30	22·0			29	21·3	29	3·2	29	9·2		
								31	21·7		

EPHEMERIS FOR PHYSICAL OBSERVATIONS OF MARS, 1886.

Greenwich Noon.	Angle of position of Mars' axis.	Areog. Lat. of centre of disk.	Diameter.	Greatest defect of illumination.	Position-angle thereof.
	°	°	"	"	°
Jan. 1	22.07	+23.39	8.88	0.76	292.33
21	23.72	22.87	10.61	0.64	290.92
Feb. 10	23.01	22.37	12.55	0.32	287.11
Mar. 2	19.75	22.00	13.87	0.02	256.90
22	15.51	21.78	13.56	0.18	121.52
Apr. 11	13.09	22.06	11.99	0.60	114.63
May 1	13.61	23.04	10.22	0.86	112.91
21	16.49	24.34	8.76	0.92	112.79
June 10	20.83	25.45	7.64	0.87	113.15
30	25.82	+25.89	6.81	0.78	113.39

Approximate Greenwich Mean Times at which the Zero-Meridian passes the Centre of Disk.

	d	h		d	h		d	h		d	h		d	h
Jan.	0	22.7	Feb.	6	21.2	Mar.	15	18.8	Apr.	21	16.7	May	28	15.8
	3	0.0		8	22.5		17	19.9		23	18.0		30	17.1
	5	1.2		10	23.7		19	21.1		25	19.3	June	1	18.4
	7	2.5		13	0.9		21	22.3		27	20.5		3	19.8
	9	3.8		15	2.1		23	23.5		29	21.8		5	21.1
	11	5.1		17	3.3		26	0.7	May	1	23.1		7	22.4
	13	6.3		19	4.5		28	1.9		4	0.3		9	23.7
	15	7.6		21	5.7		30	3.2		6	1.6		12	1.0
	17	8.8		23	6.9	Apr.	1	4.4		8	2.9		14	2.3
	19	10.1		25	8.1		3	5.6		10	4.2		16	3.7
	21	11.3		27	9.2		5	6.8		12	5.5		18	5.0
	23	12.6	Mar.	1	10.4		7	8.0		14	6.8		20	6.3
	25	13.8		3	11.6		9	9.3		16	8.0		22	7.6
	27	15.1		5	12.8		11	10.5		18	9.3		24	9.0
	29	16.3		7	14.0		13	11.7		20	10.6		26	10.3
	31	17.6		9	15.2		15	13.0		22	11.9		28	11.6
Feb.	2	18.8		11	16.4		17	14.2		24	13.2		30	12.9
	4	20.0		13	17.6		19	15.5		26	14.5			

The above table is given for every alternate day.

Intervals in Time by which certain Points on the Surface of Mars pass the Centre of the Disk after the Zero-Meridian.

No.	Mädler's letter.	Green's Name.		Schiaparelli's Name.	Areog. Long.	Interval in time.
					°	h
1.	*a*	Dawes Forked Bay.		Vertice d'Aryn 1.	0.92	0.1
2.	*d*	Terby Sea.		Lacus Solis 14.	90.87	6.2
3.	*p*	Pratt Bay.	Maraldi Sea.	Mare Sirenum 19 *a*.	131.80	9.0
4.	*r*	Trouvelot Bay.		Gigantum 25.	170.17	11.6
5.	*n*	Huggins Bay.		Mare Cimmerium 41.	239.97	16.4
6.	*f*	Kaiser Sea.		Syrtis Major 51 *c*.	281.72	19.3
7.	*e*	Banks Cape.		Hammonis Cornu 57.	317.99	21.8

The Zero-Meridian adopted in this Ephemeris passes through the point of the tongue of the "Forked Bay" of Dawes. The assumed period of the sidereal rotation of Mars is $24^h\ 37^m\ 22^s.63$.

EPHEMERIS FOR PHYSICAL OBSERVATIONS OF JUPITER, 1886.

Greenwich Noon.	Angle of Position of Jupiter's Axis.	Latitude of Earth above Jupiter's Equator.	Latitude of Sun above Jupiter's Equator.	Equatoreal Diameter.	Defect of Illumination.
	°	°	°	″	″
Jan. 3	25·216	−2·377	−1·971	37·43	0·32
23	25·191	−2·482	−2·033	39·75	0·26
Feb. 12	25·238	−2·541	−2·093	41·74	0·15
Mar. 4	25·331	−2·540	−2·152	43·43	0·04
24	25·415	−2·479	−2·208	43·91	0·00
Apr. 13	25·453	−2·376	−2·264	43·30	0·07
May 3	25·455	−2·261	−2·318	41·55	0·19
23	25·450	−2·165	−2·370	39·39	0·29
June 12	25·452	−2·106	−2·420	37·14	0·32
July 2	25·449	−2·091	−2·469	35·07	0·39
22	25·406	−2·117	−2·517	33·33	0·22
Aug. 1	25·358	−2·144	−2·539	32·60	0·18

Greenwich Mean Times at which the Red Spot passes the Central Meridian (when the passage occurs before 15h.)

	d		m		d	h	m		d	h	m		d	h	m		d	h	m
Jan.	3	11	19	Feb.	20	10	48	Mar.	27	14	31	Apr.	30	12	30	June	3	10	37
	5	12	57		22	12	26		28	10	22	May	1	8	20		4	6	28
	7	14	36		23	8	17		29	6	13		2	14	9		5	12	16
	8	10	27		24	14	4		30	12	0		3	10	0		6	8	7
	10	12	5		25	9	55		31	7	51		5	11	38		7	13	54
	12	13	43		27	11	33	Apr.	1	13	38		6	7	30		8	9	46
	15	11	10		28	7	24		2	9	29		7	13	17		10	11	24
	17	12	50	Mar.	1	13	10		4	11	7		8	9	8		11	7	16
	19	14	28		2	9	2		5	6	58		9	14	55		12	13	3
	20	10	20		3	14	48		6	12	45		10	10	46		13	8	55
	22	11	58		4	10	39		7	8	36		12	12	25		14	14	42
	24	13	36		6	12	17		8	14	23		13	8	16		15	10	33
	25	9	27		7	8	8		9	10	14		14	14	3		16	6	25
	27	11	5		8	13	55		10	6	5		15	9	54		17	12	12
	29	12	43		9	9	46		11	11	52		17	11	33		18	8	4
	31	14	21		11	11	24		12	7	43		18	7	24		19	13	51
Feb.	1	10	12		12	7	15		13	13	30		19	13	11		20	9	42
	3	11	50		13	13	2		14	9	21		20	9	2		21	5	34
	5	13	28		14	8	53		16	10	59		21	14	50		22	11	21
	6	9	19		15	14	39		17	6	50		22	10	40		23	7	13
	8	10	57		16	10	30		18	12	37		24	12	20		24	13	0
	10	12	35		18	12	8		19	8	28		25	8	10		25	8	52
	11	8	26		19	7	59		20	14	15		26	13	58		26	14	39
	12	14	12		20	13	46		21	10	6		27	9	50		27	10	30
	13	10	4		21	9	37		23	11	43		29	11	28		28	6	22
	15	11	41		23	11	15		24	7	34		30	7	20		29	12	9
	17	13	19		24	7	6		25	13	21		31	13	7		30	8	1
	18	9	10		25	12	53		26	9	12	June	1	8	58	July	1	13	48
	19	14	57		26	8	44		28	10	50		2	14	46		2	9	40

Star.	R.A.	Dec.	Star.	R.A.	
	h m s	° ′		h m s	
T Cassiopeiæ ...	0 17 4	+55 9·6	R Boötis	14 32 10	+
S Ceti	0 18 16	− 9 57·6	U Libræ	14 34 1	−
U Cephei	0 52 13	+81 15·7	δ Libræ	14 54 53	−
S Cassiopeiæ ...	1 11 17	+72 0·6	T Libræ	15 4 14	−
S Piscium	1 11 37	+ 8 19·8	U Coronæ	15 13 33	+
R Sculptoris ...	1 21 44	−33 8·1	S Libræ	15 14 51	−
R Piscium	1 24 45	+ 2 17·6	S Serpentis......	15 16 19	+
S Arietis.........	1 58 31	+11 58·8	S Coronæ	15 16 45	+
R Arietis.........	2 9 38	+24 31·2	R Coronæ	15 43 54	+
o Ceti	2 13 35	− 3 29·7	R Serpentis......	15 45 26	+
S Persei	2 14 41	+58 3·9	V Coronæ	15 45 27	+
R Ceti	2 20 12	− 0 41·6	R Libræ	15 47 9	−
T Arietis.........	2 41 58	+17 2·0	R Herculis......	16 1 6	+
Algol	3 0 45	+40 31·0	W Scorpii	16 5 6	−
R Persei	3 22 48	+35 16·9	R Scorpii	16 10 51	−
λ Tauri	3 54 22	+12 10·1	S Scorpii.........	16 10 53	−
R Tauri	4 22 3	+ 9 54·4	W Ophiuchi ...	16 15 16	−
S Tauri	4 22 57	+ 9 41·6	V Ophiuchi ...	16 20 24	−
V Tauri	4 45 26	+17 20·7	U Herculis	16 20 46	+
R Orionis	4 52 49	+ 7 57·4	T Ophiuchi......	16 27 13	−
R Leporis	4 54 25	−14 58·7	S Ophiuchi......	16 27 42	−
R Aurigæ	5 8 6	+53 27·4	W Herculis......	16 31 10	+
S Orionis.........	5 23 23	− 4 47·1	R Draconis......	16 32 21	+
η Geminorum...	6 8 0	+22 32·4	S Herculis	16 46 42	+
T Monocerotis...	6 19 4	+ 7 8·8	R Ophiuchi......	17 1 13	−
R Lyncis.........	6 51 54	+55 29·4	U Ophiuchi......	17 10 45	+
ζ Geminorum...	6 57 21	+20 44·2	X Sagittarii......	17 40 23	−
R Geminorum..	7 0 30	+22 52·7	W Sagittarii ...	17 57 45	−
R Canis Minor .	7 2 26	−10 12·1	T Herculis	18 4 47	+
L² Puppis	7 10 3	−44 27·3	T Serpentis......	18 23 15	+
V Geminorum ..	7 16 46	+13 18·5	U Sagittarii ...	18 25 10	−1
U Monocerotis...	7 25 21	− 9 32·3	β Lyræ	18 45 52	+3
S Canis Minor .	7 26 32	+ 8 33·7	R Lyræ	18 51 52	+4
T Canis Minor .	7 27 40	+11 59·3	R Aquilæ	19 0 53	+
U Canis Minor .	7 35 9	+ 8 38·7	T Sagittarii ...	19 9 40	−1
S Geminorum...	7 36 12	+23 43·1	R Sagittarii......	19 10 0	−1
T Geminorum...	7 42 28	+24 1·0	S Sagittarii......	19 12 46	−1
R Cancri.........	8 10 17	+12 4·5	R Cygni	19 33 45	+4
V Cancri.........	8 15 13	+17 38·8	S Vulpeculæ ...	19 43 43	+2
U Cancri.........	8 29 15	+19 17·3	χ Cygni	19 46 11	+3
S Cancri	8 37 25	+19 26·6	η Aquilæ.........	19 46 40	+
S Hydræ.........	8 47 37	+ 3 29·9	S Cygni	20 3 7	+5
T Hydræ.........	8 50 7	− 8 42·4	R Capricorni ...	20 4 55	−1
T Cancri.........	8 50 10	+20 17·1	S Aquilæ.........	20 6 23	+1
R Leo. Minor. .	9 38 45	+35 2·2	R Sagittæ	20 8 51	+1
R Leonis.........	9 41 26	+11 57·4	R Delphini......	20 9 25	+
R Ursæ Major .	10 36 34	+69 22·4	U Cygni	20 16 4	+4
R Crateris	10 54 57	−17 42·8	V Cygni	20 37 38	+4
S Leonis	11 4 57	+ 6 4·8	S Delphini	20 37 50	+1
R Comæ Ber....	11 58 24	+19 25·1	T Delphini	20 40 4	+1
T Virginis	12 8 46	− 5 24·1	U Capricorni ...	20 41 48	−1
R Corvi	12 13 44	−18 37·3	T Aquarii	20 43 55	−
T Ursæ Major .	12 31 12	+60 6·9	R Vulpeculæ ...	20 59 19	+2
R Virginis	12 32 43	+ 7 36·9	T Cephei.........	21 8 2	+68
S Ursæ Major..	12 38 57	+61 43·0	T Capricorni ...	21 15 43	−15
U Virginis	12 45 19	+ 6 10·0	S Cephei	21 36 37	+78
W Virginis	13 20 9	− 2 47·2	T Pegasi	22 3 20	+11
V Virginis	13 21 55	− 2 34·9	δ Cephei	22 24 56	+57
R Hydræ	13 23 30	−22 41·5	R Lacertæ	22 38 13	+41
S Virginis	13 27 3	− 6 36·5	S Aquarii	22 51 0	−20
Z Virginis	14 4 12	−12 45·8	R Pegasi	23 0 55	+ 9
V Boötis	14 25 10	+39 22·1	S Pegasi	23 14 47	+ 8
R Camelop.......	14 26 15	+84 20·9	R Aquarii	23 37 55	−15

MAXIMA AND MINIMA OF VARIABLE STARS.

M, signifies maximum; *m*, minimum.

JANUARY.

d	
1	S Hydræ, M.
2	S Vulpec., *m*.
5	R Serpent., M.
6	S Aquarii, M.
7	S Piscium, M.
10	R Lyræ, M.
10	U Monocer., *m*.
13	S Cephei, *m*.
13	R Libræ, M.
13	S Geminor., M.
14	U Virgin., *m*.
17	T Capric., M.
20	R Sagittæ, *m*.
27	T Arietis, *m*.
30	R Virgin., *m*.
31	S Libræ, M.
31	S Vulpec., M.

FEBRUARY.

2	U Capric., M.
2	U Cygni, *m*.
3	U Monocer., M.
5	R Coronæ, *m*.
7	R Arietis, M.
8	S Serpent., M.
10	R Lyræ, *m*.
13	ο Ceti, M.
15	S Herculis, M.
15	T Aquarii, *m*.
16	V Ophiuchi, M.
16	L^2 Puppis, *m*.
17	U Herculis, *m*.
17	T Pegasi, M.
20	R Vulpec., M.
20	R Crateris, *m*.
25	U Monocer., *m*.
25	R Lyræ, M.

MARCH.

d	
2	R Lyncis, M.
3	R Aquarii, M.
5	V Coronæ, *m*.
6	V Geminor., M.
10	T Cassiop., *m*.
11	S Vulpec., *m*.
12	V Tauri, M.
12	R Coronæ, M.
13	S Aquilæ, *m*.
14	T Cephei, M.
14	T Urs. Maj., M.
16	W Scorpii, M.
21	U Monocer., M.
22	R Aurigæ, *m*.
22	R Cygni, M.
24	S Ceti, M.
24	T Herculis, M.
24	T Libræ, M.
28	R Lyræ, *m*.
28	R Boötis, *m*.
29	R Sculpt., M.
30	S Urs. Maj., *m*.

APRIL.

d	
1	R Sagittæ, *m*.
3	W Herculis, *m*.
4	T Virgin., M,
5	Z Virgin., M.
5	S Sagitt., M.
8	S Vulpec., M.
9	T Can. Min., M.
10	S Coronæ, M.
10	R Virgin., M.
12	U Can. Min., *m*.
12	V Cancri, M.
12	R Lyræ, M.
12	U Monocer., *m*.
12	S Persei, M.
13	S Delphini, *m*.
14	R Hydræ, *m*.
15	S Scorpii, M.
17	R Coronæ, *m*.
19	S Ophiuchi, M.
22	S Libræ, *m*.
23	L^2 Puppis, M.
23	R Leonis, *m*.
24	U Virgin., M.
25	R Vulpec., *m*.
26	R Leporis, *m*.

MAY.

3	R Crater, M.
6	U Monocer., M.
10	R Draconis, *m*.
12	R Urs. Maj., M.
12	R Tauri, M.
13	R Lyræ, M.
15	R Ceti, *m*.
15	R Arietis, M.
15	T Aquarii, *m*.
17	V Virgin., M.
17	S Vulpec., *m*.
21	S Arietis, M.
22	R Coronæ, M.
22	R Aquilæ, M.
28	R Lyræ, *m*.
28	U Monocer., M.

JUNE.

2	R Herculis, M.
2	T Arietis, M.
2	S Boötis, M.
5	R Can. Min., *m*.
8	R Orionis, M.
10	R Sagittæ, *m*.
11	S Can. Min., *m*.
11	T Herculis, *m*.
15	S Vulpec., M.
16	R Geminor., M.
16	R Lacertæ, M.
18	R Persei, M.
21	U Monocer., M.
23	T Delphini, M.
25	R Virgin., *m*.
25	R Pegasi, M.
27	R Coronæ, *m*.
28	R Lyræ, *m*.

Maxima and Minima of Variable Stars (continued).

JULY.

d	
1	R Vulpec., M.
1	L² Puppis, *m.*
3	S Leonis, M.
4	S Herculis, *m.*
4	R Ophiuchi, M.
8	R Boötis, M.
11	R Capric., M.
12	R Sagitt., M.
12	T Sagitt., M.
13	U Monocer., *m.*
13	R Lyræ, M.
15	U Libræ, M.
18	χ Cygni, *m.*
22	V Boötis, M.
22	S Delphini, M.
23	R Piscium, M.
24	S Vulpec., *m.*
24	S Urs. Maj., M.
29	η Geminor., M.
30	R Crateris, *m.*
31	R Scorpii, M.

AUGUST.

d	
1	S Virgin., *m.*
1	R Coronæ, M.
5	V Coronæ, M.
6	U Monocer., M.
7	S Aquilæ, *m.*
8	T Cancri, M.
10	T Urs. Maj., *m.*
10	U Virgin., *m.*
11	R Camelop., M.
12	S Libræ, M.
12	R Arietis, M.
13	R Lyræ, *m.*
17	R Comæ, M.
17	T Hydræ, M.
18	W Herculis, M.
19	R Sagittæ, *m.*
20	R Cancri, M.
21	S Vulpec., M.
24	U Herculis, M.
24	U Capric., M.
26	R Draconis, M.
27	V Tauri, M.
28	U Monocer., *m.*
28	R Lyræ, M.
31	R Leo. Min., M.

SEPTEMBER.

d	
2	R Virgin., M.
3	R Vulpec., *m.*
4	R Corvi, M.
4	T Serpent., M.
5	L² Puppis, M.
5	S Pegasi, M.
5	T Herculis, M.
6	T Aquarii, *m.*
6	R Coronæ, *m.*
7	R Delphini, M.
15	S Hydræ, M.
18	R Leonis, M.
20	T Cephei, *m.*
20	U Cygni, M.
21	U Monocer., M.
24	S Cygni, M.
25	U Cancri, M.
26	*o* Ceti, *m.*
28	R Lyræ, *m.*
29	S Vulpec., *m.*

OCTOBER.

d	
1	T Geminor., M.
6	R Aquilæ, M.
9	S Scorpii, M.
10	R Crateris, M.
10	S Cassiop., M.
12	S Aquarii, M.
12	R Coronæ, M.
13	U Monocer., *m.*
13	R Lyræ, M.
13	T Capric., M.
15	V Cygni, M.
21	R Can. Min., M.
22	R Sculpt., M.
26	W Scorpii, M.
28	S Vulpec., M.
29	R Sagittæ, *m.*
29	R Ceti, M.
31	T Ophiuchi, M.

NOVEMBER.

d	
1	S Orionis, M.
1	S Libræ, *m.*
2	R Hydræ, M.
3	S Geminor., M.
4	S Cephei, M.
6	U Monocer., M.
6	R Boötis, *m.*
7	S Coronæ, *m.*
9	T Cassiop., M.
9	R Vulpec., M.
10	R Aurigæ, M.
13	R Lyræ, *m.*
13	L² Puppis, *m.*
14	S Urs. Maj., *m.*
15	W Ophiuchi, M.
17	R Coronæ, *m.*
18	U Can. Min., M.
18	R Arietis, *m.*
18	U Virgin., M.
18	R Virgin., *m.*
21	S Sagitt., M.
23	T Herculis, *m.*
24	S Can. Min., M.
28	U Monocer., *m.*
28	R Lyræ, M.
29	T Urs. Maj., M.
30	S Virgin., M.

DECEMBER.

d	
5	T Aquarii, M.
6	S Vulpec., *m.*
7	V Geminor., M.
9	S Ophiuchi, M.
12	R Leporis, M.
15	S Herculis, M.
16	T Arietis, *m.*
18	S Tauri, M.
22	U Monocer., M.
22	R Coronæ, M.
24	V Ophiuchi, M.
29	R Lyræ, *m.*
29	R Serpent., M.

MINIMA [illegible]

Minima of Variable Stars of the Algol Type (continued).

ALGOL.

	d	h	m
December.	3	14	27
	6	11	15
	9	8	5
	12	4	54
	15	1	43
	17	22	32
	20	19	21
	23	16	9
	26	12	58
	29	9	47

λ TAURI.

	d	h	m
January.	1	23	8
	5	22	0
	9	20	52
	13	19	45
	17	18	37
	21	17	29
	25	16	21
	29	15	14
February.	2	14	6
	6	12	58
	10	11	51
	14	10	43
	18	9	35
	22	8	28
	26	7	20
March.	2	6	12
	6	5	4
	10	3	57
August.	3	10	12
	7	9	4
	11	7	56
	15	6	49
	19	5	41
	23	4	33
	27	3	26
	31	2	18
September.	4	1	10
	8	0	3
	11	22	55
	15	21	47
	19	20	39
	23	19	32
	27	18	24

λ TAURI.

	d	h	m
October.	1	17	16
	5	16	9
	9	15	1
	13	13	53
	17	12	46
	21	11	38
	25	10	30
	29	9	22
November.	2	8	15
	6	7	7
	10	5	59
	14	4	52
	18	3	44
	22	2	36
	26	1	29
	30	0	21
December.	3	23	13
	7	22	5
	11	20	58
	15	19	50
	19	18	42
	23	17	35
	27	16	27
	31	15	19

S CANCRI.

	d	h	m
Jan.	9	3	45
	18	15	23
	28	3	1
Feb.	6	14	39
	16	2	16
	25	13	54
Mar.	7	1	32
	16	13	10
	26	0	47
April.	4	12	25
	14	0	3
	23	11	41
May.	2	23	18
	12	10	56
	21	22	34
	31	10	12

S CANCRI.

	d	h	m
June.	9	21	49
	19	9	27
	28	21	5
Sept.	3	6	29
	12	18	7
	22	5	45
Oct.	1	17	22
	11	5	0
	20	16	38
	30	4	16
Nov.	8	15	53
	18	3	31
	27	15	9
Dec.	7	2	47
	16	14	24
	26	2	2

δ LIBRÆ.

	d	h	m
January.	2	22	22
	5	6	13
	7	14	4
	9	21	56
	12	5	47
	14	13	38
	16	21	30
	19	5	21
	21	13	12
	23	21	4
	26	4	55
	28	12	46
	30	20	38
February.	2	4	29
	4	12	20
	6	20	12
	9	4	3
	11	11	54
	13	19	46
	16	3	37
	18	11	28
	20	19	20
	23	3	11
	25	11	2
	27	18	54

δ LIBRÆ.

	d	h	m
March.	2	2	45
	4	10	36
	6	18	28
	9	2	19
	11	10	10
	13	18	2
	16	1	53
	18	9	44
	20	17	36
	23	1	27
	25	9	18
	27	17	10
	30	1	1
April.	1	8	52
	3	16	44
	6	0	35
	8	8	26
	10	16	18
	13	0	9
	15	8	0
	17	15	52
	19	23	43
	22	7	34
	24	15	26
	26	23	17
	29	7	8
May.	1	15	0
	3	22	52
	6	6	43
	8	14	34
	10	22	25
	13	6	16
	15	14	8
	17	21	59
	20	5	50
	22	13	42
	24	21	33
	27	5	24
	29	13	16
	31	21	7
June.	3	4	58
	5	12	50
	7	20	41
	10	4	32
	12	12	24
	14	20	15
	17	4	6
	19	11	58
	21	19	49
	24	3	40
	26	11	32
	28	19	23

δ L

July.

August.

September.

Oct.

December.

[illegible]

Coron[illegible]

January.

February.

March.

April.

May.

June.

June

July

August

September

October

November

December

VARIABLES OF SHORT PERIOD NOT OF THE ALGOL T

Note.—The times of minima only are given; the times of maxima may be foun adding the interval printed under the name of the star.

T MONOCEROTIS.
(8d·0.)

	d		d
Jan.	15·2	Aug.	19·1
Feb.	11·1	Sept.	15·1
Mar.	10·1	Oct.	12·0
Apr.	6·1	Nov.	8·0
May	3·1	Dec.	5·0

ζ GEMINORUM.
(5d·0.)

	d		d
Jan.	7·6	Aug.	19·0
	17·7		29·1
	27·9	Sept.	8·3
Feb.	7·0		18·5
	17·2		28·6
	27·4	Oct.	8·8
Mar.	9·5		18·9
	19·7		29·1
	29·8	Nov.	8·2
Apr.	9·0		18·4
	19·1		28·5
	29·3	Dec.	8·7
May	9·4		18·8
	19·6		29·0

W VIRGINIS.
(8d·2.)

	d		d
Jan.	13·0	May	31·2
	30·3	June	17·4
Feb.	16·5	July	4·7
Mar.	5·8		22·0
	23·1	Aug.	8·3
Apr.	9·3		25·5
	26·6	Dec.	7·2
May	13·9		24·4

X SAGITTARII.
(2d·9.)

	d		d
Mar.	2·5	May	4·6
	9·5		11·6
	16·5		18·6
	23·5		25·6
	30·5	June	1·7
Apr.	6·6		8·7
	13·6		15·7
	20·6		22·7
	27·6		29·7

X SAGITTARII (*continued*).

	d		d
July	6·7	Aug.	31·8
	13·7	Sept.	7·8
	20·7		14·8
	27·8		21·8
Aug.	3·8		28·9
	10·8	Oct.	5·9
	17·8		12·9
	24·8		19·9

W SAGITTARII.
(3d·2.)

	d		d
Feb.	23·6	June	25·1
Mar.	3·2	July	2·7
	10·8		10·3
	18·4		17·9
	26·0		25·5
Apr.	2·6	Aug.	2·1
	10·2		9·7
	17·8		17·3
	25·4		24·9
May	3·0	Sept.	1·5
	10·6		9·1
	18·2		16·7
	25·8		24·3
June	2·4	Oct.	1·9
	10·0		9·4
	17·5		17·0

U SAGITTARII.
(3d·0.)

	d		d
Mar.	2·7	June	5·1
	9·4		11·9
	16·2		18·6
	22·9		25·3
	29·7	July	2·1
Apr.	5·4		8·8
	12·1		15·6
	18·9		22·3
	25·6		29·1
May	2·4	Aug.	4·8
	9·1		11·6
	15·9		18·3
	22·6		25·0
	29·4		31·8

U SAGITTARI (*continued*).

	d		
Sept.	7·5	Oct.	
	14·3		
	21·0		
	27·8		
Oct.	4·5	Nov.	

β LYRÆ.
(Max. 3d·2. Seco
Min. 6d·5. Max.

	d		
Jan.	6·4	July	
	19·3		
Feb.	1·2	Aug.	
	14·1		
	27·0		
Mar.	11·9	Sept.	
	24·9		
Apr.	6·8	Oct.	
	19·7		
May	2·6		
	15·5	Nov.	
	28·4		2
June	10·3	Dec.	
	23·2		2

η AQUILÆ.
(2d·4.)

	d		
Mar.	7·7	July	2
	14·9		2
	22·1	Aug.	
	29·2		1
Apr.	5·4		1
	12·6		2
	19·8	Sept.	
	27·0		1
May	4·1		1
	11·3		2
	18·5	Oct.	1
	25·7		
June	1·8		1
	9·0		2
	16·2		3
	23·4	Nov.	
	30·5		13
July	7·7		21
	14·9		28

VARIABLES OF SHORT PERIOD (*continued*).

δ CEPHEI. ($1^{d}·6$.)

	d		d		d		d		d		d
Jan.	6·2	Mar.	11·6	May	15·0	July	18·4	Sept.	20·8	Nov.	24·2
	11·6		17·0		20·4		23·8		26·2		29·6
	16·9		22·3		25·7		29·1	Oct.	1·5	Dec.	4·9
	22·3		27·7		31·1	Aug.	3·5		6·9		10·3
	27·7	Apr.	2·1	June	5·5		8·9		12·3		15·7
Feb.	2·0		7·4		10·8		14·2		17·6		21·0
	7·4		12·8		16·2		19·6		23·0		26·4
	12·8		18·2		21·6		25·0		28·4		31·8
	18·1		23·5		26·9		30·3	Nov.	2·7		
	23·5		28·9	July	2·3	Sept.	4·7		8·1		
	28·9	May	4·3		7·7		10·1		13·5		
Mar.	6·2		9·6		13·0		15·4		18·8		

REMARKABLE NEBULÆ AND CLUSTERS.

No.	Name of Constellation.	H.	R.A. 1880.	Dec. 1880.	Remarks.
			h m		
1.	47 Toucani	52	0 19	−72 45	Immense globular cluster. Stars in centre ruddy, the rest white.
2.	Andromeda......	116	0 36	+40 35	Great Andromeda Nebula, Messier 31.
3.	Cetus	138	0 42	−25 53	Elliptic, 24′×3′.
4.	Perseus	512	2 11	+56 36	Two fine clusters, visible to naked eye.
5.	Perseus	584	2 34	+42 16	Just visible to naked eye.
6.	Taurus............	1157	5 27	+21 56	"Crab Nebula."
7.	Orion	1179	5 29	− 5 28	Great Orion Nebula.
8.	30 Doradûs......	1269	5 40	−69 10	"Great looped nebula," naked eye.
9.	Auriga	1295	5 44	+32 32	Magnificent, resolvable.
10.	Gemini	1360	6 1	+24 21	Naked eye.
11.	Canis Majoris...	1454	6 42	−20 37	Naked eye, 4° S. of Sirius.
12.	Argo Navis......	1619	7 57	−60 33	Naked eye; orange star in middle.
13.	„ „	1636	8 7	−48 55	Naked eye; 7–16 mag.
14.	Ursa Major......	1949 1950	9 46	+69 41	½° apart.
15.	η Argûs	2197	10 40	−59 3	Large diffused milky nebula.
16.	Ursa Major......	2343	11 8	+55 40	Planetary.
17.	κ Crucis	3275	12 47	−59 42	50 to 100 stars.
18.	Coma Berenices.	3453	13 7	+18 47	Brilliant mass of stars.
19.	ω Centauri	3531	13 20	−46 41	"Thousands of stars."
20.	Canes Venatici .	3572	13 25	+47 49	"Spiral" resolvable.
21.	Canes Venatici .	3636	13 37	+28 58	"1000 small stars."
22.	Libra	4083	15 12	+ 2 32	
23.	Scorpio	4173	16 10	−22 42	Rich mass of stars.
24.	Hercules	4230	16 37	+36 41	Superb globular cluster.
25.	Hercules	4294	17 13	+43 16	Fine cluster, resolvable.
26.	Clypeus Sobieski	4403	18 14	−16 15	The "Horseshoe" nebula.
27.	Antinoüs.........	4437	18 45	− 6 24	Magnificent fan-shaped cluster.
28.	Lyra	4447	18 49	+32 53	"Ring nebula."
29.	Vulpecula	4532	19 54	+22 23	"Dumb Bell," visible in 1½ in.
30.	Andromeda......	4964	23 21	+41 52	Very bright.
31.	Cassiopeiæ	5031	23 51	+56 3	Largs faint cloud of small stars.

STARS WITH REMARKABLE SPECTRA.

The great majority of the stars visible to the naked eye have spectra whi may be grouped under one of two types:—(1) those spectra which are cross by four broad dark ill-defined lines corresponding to hydrogen, and with f or no traces of metallic lines; and (2) those in which, as in the solar spectru the hydrogen lines are much less conspicuous, and which show a great numb of narrow lines due to the metals. Amongst the brightest in each class find:—

Class I.—α, μ Andromedæ; ζ, Aquarii; α, δ, ζ, η, θ, λ Aquilæ; β Arieti β, η, θ Aurigæ; γ Boötis; α, β, γ, ε, η Canis Majoris; β Canis Minoris; β, ε Cassiopeiæ; α Cephei; γ Ceti; α, β, γ Coronæ Borealis; γ, δ Corvi; δ Cygn α, ε Delphini; α, ζ Draconis, α, γ, δ, θ, ξ Geminorum; γ, δ, ε, μ Herculis; β, δ, ζ, η Leonis; α, ε, ζ, η Leporis; α, β Libræ; α, γ Lyræ; α, λ, γ Ophiuch α, γ, ζ Pegasi; α, β, γ, δ Persei; α Piscis Australis; α Piscium; β Scorpii; μ Serpentis; β, η, ξ Tauri; β Trianguli; β, γ, δ, ε, ζ, η Ursæ Majoris; α, γ, η Virginis.

Class II.—β, γ, δ, λ, ο Andromedæ; α, β Aquarii; β, γ, ε Aquilæ; α Arieti α, δ, ε, ζ, ι Aurigæ; α, β, δ, ε, η, ρ Boötis; δ Canis Majoris; α^1, α^2 Capricorni α, ζ, η Cassiopeiæ; β, γ, ζ, η Cephei; β, ζ, η, θ, ι Ceti; β Corvi; α, β, γ, ε, ζ, Cygni; β Delphini; β, γ, η, θ, ι, ξ, χ Draconis; β Geminorum; β, ζ, η, Herculis; α, ε, ζ Hydræ; γ, ε, μ Leonis; β, γ Leporis; β, ε, κ Ophiuchi ε, η, μ Pegasi; ε, ζ Persei; η Piscium; δ Scorpii; α Serpentis; α, γ, δ′, ε, Tauri; α Trianguli; α Ursæ Majoris; β Ursæ Minoris; β, ε Virginis.

Procyon and Polaris seem to offer spectra of a type intermediate between th first and second classes.

The principal stars of Orion, with the exception of α Orionis, form a sub division of Class I.; the hydrogen lines being still the principal lines of th spectrum, but far fainter and narrower than is usual in stars of the class.

Betelgeuse, α Orionis, appears to present a spectrum intermediate betwee the second and a third class; the third class being those that are crossed b dark shaded bands which terminate for the most part in a very dark sharp edg towards the violet, and gradually shade away towards the red. The brightes stars of this class are as follows:—

Class III.—λ, φ, χ Aquarii; π, ρ Arietis; π, υ Aurigæ; υ Boötis; μ Cephei α, ο, υ Ceti; ν^1, ν^2 Coronæ; ω^3, χ Cygni; λ Draconis; γ, π Eridani; η, μ Geminorum; α Herculis; π, ψ Leonis; δ^2 Lyræ; δ Ophiuchi; ο′ Orionis; β, φ Pegasi ρ Persei; δ Piscium; δ Sagittæ; α Scorpii; κ, τ′ Serpentis; ρ, μ Ursæ Majoris δ, ψ, σ Virginis; α Vulpeculæ.

The following stars are also fine examples of the type. The places are given for 1886·0.

Star's Name.	R.A.			Dec.		Star's Name.	R.A.			D
	h	m	s	°	′		h	m	s	°
R Andromedæ	0	18	1	+37	56·7	DM. +47°·2291 ...	15	59	14	+47
20 Leporis	5	6	3	−11	50·4	g Herculis	16	24	53	+42
119 Tauri	5	25	32	+18	30·5	407 Birmingham ...	17	14	2	+ 2
51 Geminorum	7	6	49	+16	21·2	R Lyræ	18	51	52	+43
R Leonis	9	41	20	+11	57·5	569 Birmingham ...	20	40	15	+17
56 Leonis	10	50	5	+ 6	4[illegible]	3 Aquarii	20	41	44	− 5
40 Comæ Ber.	13	0	49	+23	15·8	LL 42153	21	31	42	+44
R Hydræ	13	23	29	−22	41·4	DM. +14°·4730 ...	21	59	33	+14
169 Schjellerup......	14	19	4	+20	15·4	615 Birmingham ...	22	34	8	+56
LL 26918	14	40	23	+15	30·6	71 Pegasi	23	27	46	+21
342 Birmingham ...	14	55	46	+66	25·2	30 Piscium	23	56	7	− 6

R Andromedæ presents some differences from ordinary third type spectra.

STARS WITH REMARKABLE SPECTRA (*continued*).

The fourth class, which embraces those spectra in which the dark bands have their darkest edge on the side nearer the red, and shade away towards the violet, contains very few stars visible to the naked eye. The following are the most remarkable examples:—

Star's Name.	R.A.	Dec.	Star's Name.	R.A.	Dec.
	h m s	° ′		h m s	° ′
DM. +57°·702	3 2 40	+57 28·2	DM. +68°·617	10 37 9	+68 0·6
51 Schjellerup	4 59 28	+ 1 1·2	152 Schjellerup	12 39 46	+46 3·8
72 Schjellerup	6 3 49	+26 2·1	155 *b* Schjellerup	12 51 57	+66 36·6
78 Schjellerup	6 28 42	+38 32·2	229 Schjellerup	19 25 33	+76 20·1
115 Schjellerup	8 48 57	+17 39·9	249 *a* Schjellerup	21 37 13	+34 59·4
132 Schjellerup	10 31 54	−12 47·6	19 Piscium	23 40 34	+ 2 51·3

Besides the above-named four types there are a few stars which show the lines of hydrogen bright in their spectra. Only three bright stars belong to this class—γ Cassiopeiæ, β Lyræ, and η Argûs. The following small stars have bright lines in their spectra, but the lines do not appear to be those of hydrogen:—

Star's Name.	R.A.	Dec.	Star's Name.	R.A.	Dec.
	h m s	° ′		h m s	° ′
LL. 13412	6 49 12	−23 46·8	B.D. +35°·4013	20 7 24	+35 50·6
Arg.-Oeltzen 17681	18 1 17	−21 16·3	B.D. +36°·3956	20 10 4	36 17·8
B.D. +35°·4001	20 5 46	+35 49·5			

BINARY STARS.

The following are amongst the best known and most remarkable:—

No.	Name of Star.	R.A. 1880.	Dec. 1880.	Mag.	Position.	Distance.	Epoch. 1800+.	Observer.
		h m	° ′		°	″		
1.	η Cassiopeiæ	0 41·8	+57 11	4 ; 8	165·7	5·16	82·87	E.
2.	56 Andromedæ	0 48·3	+22 58	6 ; 7	1·0	1·46	83·32	E.
3.	*p* Eridani	1 35·2	−56 49	6 ; 6	230·5	7·10	85·19	T.
4.	ι Cassiopeiæ AB	2 19·2	+66 51	4 ; 7	82·0	2·23	83·67	E.
5.	,, AC	,,	,,	4 ; 8	110·0	7·43	83·52	E.
6.	γ Ceti	2 37·1	+ 2 44	3 ; 7	286·0	3·04	77·99	H.
7.	98 Eridani	3 30·6	+ 0 12	6 ; 8	241·9	6·47	80·02	H.
8.	40 ,, AB	4 9·8	− 7 49	4 ; 9	105·6	81·90	79·18	H.
9.	2 Camelopardalis	4 30·4	+53 15	5 ; 7	291·9	1·87	82·93	E.
10.	ι Orionis OΣ 98	5 1·3	+ 8 20	6 ; 7	205·8	0·89	79·10	H.
11.	118 Tauri	5 21·9	+25 3	6 ; 7	198·2	5·04	76·16	H.
12.	12 Lyncis AB	6 35·6	+59 34	5 ; 6	128·4	1·70	82·76	E.
13.	,, AC	,,	,,	5 ; 7	126·7	8·29	82·20	E.
14.	Sirius AB	6 39·9	−16 32	1 ; 12	114·9	71·39	77·47	H.
15.	38 Geminorum	6 47·3	+13 20	5 ; 8	163·4	6·19	82·89	E.
16.	Castor AB	7 27·0	+32 9	2 ; 3	234·3	5·56	82·88	E.

DOUBLE STARS, TEST-OBJECTS, &c. (*continued*).

No.	Star's Name.	R.A.	Dec. 1880.	Mag.	Pos.-angle.	Dist.	Re
		h m	° ′		°	″	
49.	κ Boötis	14 9	+52 21	5·5; 8	238	13	Pale white;
50.	Σ 1835	14 18	+ 9 0	6; 7·5	186	6	Golden yellow
51.	π Boötis.....	14 35	+16 56	3·5; 6	99	6	White; crea
52.	α^2 Libræ	14 44	−15 33	3; 6	314	229	Pale yellow;
53.	β Libræ	15 11	− 8 56	......	......	......	Pale green.
54.	β Scorpii	15 58	−19 29	2; 5·5	25	13	A is double.
55.	κ′ Herculis.........	16 3	+17 22	5·5; 7	10	31	Pale yellow;
56.	ν Scorpii	16 5	−19 9	4; 7	339	40	Both double.
57.	ν^2 Coronæ Ber....	16 18	+33 59	5; 12	18	137	Yellow; garn
58.	α Herculis.........	17 9	+14 32	3·5; 5·5	119	5	Golden; emer
59.	39 Ophiuchi	17 11	−24 9	5·5; 7·5	356	12	Pale gold; bl
60.	μ Herculis.........	17 42	+27 48	4; 10	242	30	Pale straw;
61.	67 Ophiuchi	17 55	+ 2 56	4; 8	144	55	Straw-coloure
62.	95 Herculis	17 56	+21 36	5·5; 6	262	6	Fine contrast
63.	Vega	18 33	+38 40	1; 11	......	46	Companion te
64.	46 Draconis	18 40	+55 25	5; 9	......	......	Fine contrast
65.	ζ Lyræ	18 41	+37 29	4; 6·5	150	44	Golden; gree
66.	β Lyræ	18 46	+33 13	......	......	......	Three small c
67.	δ Lyræ	18 50	+36 49	......	......	......	Fine low-pow
68.	θ′ Serpentis	18 50	+ 4 3	4·5; 5	104	22	Fine pair in g
69.	Σ 2428	18 54	+14 45	8·5; 10·5	289	6·5	Fine test-obje
70.	Σ 2486	19 9	+49 37	6; 6·5	225	11	Beautiful field
71.	θ Lyræ	19 12	+37 55	5; 10	......	......	Fine field.
72.	β Cygni	19 26	+27 42	3; 7	56	34	Superb pair.
73.	γ Aquilæ	19 41	+10 19	......	......	......	Beautiful field
74.	χ Cygni	19 42	+33 27	5; 9	73	26	Beautiful field
75.	π Aquilæ	19 43	+11 31	6; 7	121	1·7	Test.
76.	Σ 2590	19 47	+10 3	7; 13	308	15	Light test.
77.	ε Draconis.........	19 49	+69 58	5·5; 9·5	1	2·9	(1877.) Ligh
78.	o^2 Cygni............	20 10	+46 23	......	......	......	Fine triple.
79.	α Capricorni	20 11	−12 55	3; 4	291	373	Both yellow.
80.	κ Cephei	20 13	+77 21	4·5; 8·5	124	7	Pale yellow; b
81.	β^2 Capricorni ...	20 14	−15 10	3·5; 7	267	205	Very fine field.
82.	ρ Capricorni	20 22	−18 13	5; 9	177	3·8	White; pale b
83.	o^2 Capricorni......	20 23	−18 59	6; 7	240	22	Bluish.
84.	12 Aquarii.........	20 58	− 6 18	5·5: 8·5	191	2·8	White; blue.
85.	Σ 2747	20 58	+37 10	8·2; 8·2	257	5	White.
86.	β Equulei	21 17	+ 6 18	......	......	......	Quadruple. T
87.	1 Pegasi............	21 17	+19 17	4; 9	311	36	Deep yellow;
88.	β Cephei	21 27	+70 2	3; 8	251	14	Yellow; violet
89.	ε Pegasi	21 38	+ 9 20	2·5; 14; 9	...	......	Triple.
90.	κ Pegasi............	21 39	+25 6	4; 12	311	36	Good light-test
91.	μ Cephei	21 40	+58 14	......	......	......	The “Garnet
92.	π′ Pegasi	22 4	+32 35	......	......	......	A fine pair wit
93.	53 Aquarii.........	22 20	−17 21	6·5; 6·5	301	10	Both pure whi
94.	δ Cephei	22 25	+57 48	4·5; 7	19[illegible]	41	Deep yellow;
95.	Σ 2978	23 2	+32 11	7; 8·5	146	8	White; blue.
96.	ψ′ Aquarii.........	23 10	− 9 44	5·5; 9	310	49	Golden; sky-b
97.	94 Aquarii.........	23 13	−14 7	6; 8·5	345	14	Pale rose; ligh
98.	OΣ 496	23 24	+57 53	5; 7·5	270	74	Companion do
99.	ω^2 Aquarii.........	23 37	−15 12	5; 12	90	3	Test for 5-in.
100.	σ Cassiopeiæ	23 53	+55 5	6; 8	324	3	Fine low-powe

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OBSERVATORY,

LY REVIEW OF ASTRONOMY.

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CONTENTS.

PAGE
ical Society on December 11, 1885 49
omical Society 60

the Rev. Prof. C. Pritchard, F.R.S. 62
J. Rand Capron, F.R.A.S. 63
(Fabry), made at Mr. Wigglesworth's Obser-
Cooke Refractor. By Dr. J. Gerh. Lohse ... 64
antes du 27 novembre, 1885, en Italie. By
.... 65
E. W. Maunder, F.R.A.S. 68

a. By Maxwell Hall, M.A., F.R.A.S. 69
ons. By Prof. T. H. Safford, For. Assoc.
.... 71
rability of Mean Motions in a System. By
.... 72
F.R.A.S. 74
its. By W. H. S. Monck, M.A. 74
eors in the Great Showers of November 27,
Denning, F.R.A.S. 76
iel Kirkwood 77

gni, Albireo.—Search for the Trans-Neptunian
Stellar Spectra.—Cape Observations.—Olbers's
or Planets 78, 79
omet 1885 *d* (Fabry) 80
omet 1885 *e* (Barnard) 80
.... 80

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Mr. Knobel read a paper by *Mr. Neison* on the term of long period due to Mars in the expression for the longitude of the Moon. The paper referred to a criticism of a former paper on the subject. M. Gogou had given an elaborate criticism of a short paper intended only to give results of a provisional calculation which was stated to need revision and extension; and, further, that having calculated certain additional terms which he (Mr. Neison) had declared to be insensible, M. Gogou had only arrived at the same result.

Mr. Stone. I should be glad to ask if Mr. Neison considers the results he gives as correct, or whether he admits that the result which M. Gogou has given is correct. That seems to me to be the important point. The inequality was supposed to account for certain discordances between theory and observation, which amount to a considerable quantity. As far as I understand, M. Gogou's calculations allude to a quantity which amounts to only about one tenth of a second.

Prof. Adams. I do not understand that Mr. Neison at all contends for the accuracy of his first published result. That made the inequality spoken of rather larger, amounting to 7 seconds, whereas M. Gogou finds that very same inequality arising in the same way to be only a few hundredths of a second instead of 7 seconds. I think Mr. Neison's contention here is, that it was quite unnecessary for M. Gogou to calculate the terms, because he declared them to be insensible, and according to M. Gogou the whole inequality, as far as he has gone, is perfectly insensible.

Mr. Knobel. Mr. Neison states here that M. Gogou's paper is an elaborate criticism of his first provisional calculation, which only occupied three pages of the 'Notices,' and which was a calculation, stated at the time to be merely provisional and approximate, needing careful revision and extension, which is rather an admission that he does not hold to it.

A vote of thanks was then accorded to Mr. Neison.

Mr. Ranyard read a paper on the connection between photographic action, the brightness of a luminous object, and the time of exposure, as applied to celestial photography. The object, Mr. Ranyard explained, was to obtain a comparison between the sensitiveness of the eye and the sensitiveness of a photographic film for detecting small differences of illumination. With the eye a difference of $\frac{1}{60}$ in the intensity of illumination of two adjacent fields can be detected when the illumination is not too brilliant and when the illuminated areas are of sufficient extent. In the last number of the 'Notices,' Prof. Pritchard had stated that he thought he could detect the difference in illumination to $\frac{1}{120}$ under certain circumstances. There was no doubt that $\frac{1}{60}$ could be detected in a large area if the illumination was not too bright. But with photographic plates the difference that could be detected was not, according to his experiments, more than $\frac{1}{18}$ or $\frac{1}{19}$. He had made experiments by successive exposures of equal duration of adjacent parts of the same plate, the source of light being a candle placed at measured and varying distances. The plates were afterwards examined by the eye, so as to judge of the density of the deposited silver after the development. The exposures were made with the greatest possible accuracy, being governed by the driving-clock of his telescope. The result of the examination of the plates seemed to show that the density increased directly with the length of the exposure and with the brightness of the illumination, and in inverse proportion to the square of the distance of the light. The experiments were made with all kinds of dry plates and with candle-light. Exposing different parts of plates successively every $7\frac{1}{2}$ seconds resulted in a number of steps down the plate, amounting to twenty or thirty steps. The utmost number that could be detected by the eye was eighteen or nineteen with the best plates, and five or six with the common plates. The difference between the 18th and 19th was just visible, whereas the eye itself could detect a difference of $\frac{1}{60}$. The human eye therefore could detect a much less difference than the photographic plate could record. The degree of development of a plate might make some difference, because a plate might be so slightly developed that the faintest steps would not be registered at all. These experiments might have an important bearing on eclipse questions, and the question of photographing the corona of the Sun in the daytime. There was evidence that the corona was very faint compared with the illumination round the Sun; and during an eclipse the corona was not visible at all on the dark side of the Moon till a minute or so before totality, when the illumination of the air was reduced to much less than $\frac{1}{100}$ of the air illumination during full sunlight. He therefore saw no chance of attaining that very much longed-for opportunity of tracing the corona from day to day. As Captain Abney was now present he might mention that in making the exposures of the plates with the dark slide, he at first thought he could distinguish a difference of tint with exposures differing as 30 and 31; but on looking more closely at the negative he found that the steps were divided by little dark lines, which were really due to reflection of light from the bottom of the slide, and when the bottom of the slide was shaded by a little metal shade, the dark lines were entirely lost. Prof. W. H. Pickering had made some similar experiments with American plates, and had arrived at the conclusion that a difference of tint corresponding to a difference of 5 per cent. in illumination could not be seen.

Mr. Common. If Mr. Pickering could not photograph the Moon in daylight, which has been done here, his experiments as to photographing changes of light will not go for much.

Mr. Ranyard. Think of the difference in the way in which these photographs were taken here and there. Here it was photographed with a reflector, and there it was attempted to be photographed in the ordinary photographic camera. In the case you get an image of the Moon with considerable ma fication, and in the other you do not; but you get a decreas the atmospheric illumination.

Capt. Abney. I consider that the experiments made by Ranyard are rather a rude way of getting the relative values of posures. It by no means follows that more exposure and incr of brightness are synonymous. This is a very important point but little attended to; but I think I may say that a double expo is not equal to the double brightness of an object. In some exp ments I made recently, and which I hope shortly to bring before Society, I think I could detect a difference of about $\frac{119}{120}$ inten in the shadow, and therefore I am not prepared to say that ph graphing the corona in daylight is impossible—more especi as I think Mr. Ranyard's theory goes upon false premises. V reference to the action of light upon the eyes I know it is difficult to estimate very close gradations of shadow. If, for stance you take a water spectrum in a 3-foot tube of water pl before the slit of a spectroscope, and examine the spectrum, ap rently you get no absorption of the visible part; but if you r sure it photometrically you will find there is a place in the yel just on the green side of D, in which there is absorption, and this absorption (for three feet of water) is about $\frac{1}{120}$ part of light at that part of the spectrum. It is a perfectly defi absorption, though you cannot detect it by the eye when you the brightest parts. A photograph with proper exposure show it at once. Therefore with the photograph you have a gre amount of sensitiveness and gradation than you have with the

Mr. Ranyard. In the first part of my paper, which Cap Abney did not hear, I went rather carefully into the quest whether the photographic density does increase regularly with light; and I have a number of plates which seem to show that density of the plate with the same development varies with brightness and with the exposure.

Mr. Brett remarked that the use of the word "shade" is confusing. You do not see shade, it is the light you see.

Capt. Abney. I have had the misfortune to write several bo and in an early book of 1876, published by Longmans, Mr. Ran will see a fairly accurate scale of shading in regard to the inten of negatives with varying exposures, and he will see also that perfectly feasible, according to those charts, to distinguish minute differences in shading, much smaller than the $\frac{1}{20}$ p which he seems to have arrived at as his result.

Col. Tupman. The Society has received a great many obse tions of the star-shower of the 27th November. There are c plete observations from Father Denza; Prof. Schiaparelli; Denning, Bristol; Prof. Pritchard at Oxford; Prof. Gr Glasgow; Dr. Copeland, Dun Echt; Mr. Rand Capron;

Howlett; Col. Ward; and others. It will of course be understood that these papers cover very much the same ground. Most of them deal with the determination of the time of the maximum display, the intensity of the meteors, and the determination of the radiant. Some of them draw comparisons with the shower as seen in 1872. Perhaps the most interesting single feature is the observations by Dr. Copeland. Perhaps Lord Crawford would like to say something about them.

Lord Crawford. On the night of the 27th November, 1878, Dr. Copeland and myself watched at Dun Echt for the greater part of eight hours for any possible return of the Biela meteors of 1872. So far as the meteors in question were concerned, the immediate result was almost entirely negative, for scarcely a meteor was seen referable to the radiant in Andromeda. The conclusion was obvious that the meteors were not by any means evenly distributed round the orbit of the lost comet. Taking the correct period of the comet as given by Herschel, viz. 6 years 202 days, it became evident that 1885, Nov. 27, would fall only forty days short of the completion of the second period that had elapsed since the grand display in 1872, and would afford the best chance of witnessing a repetition of it, and this fact was communicated to the Society. From the 22nd to the 26th November the sky was unusually clouded at Dun Echt, so that no telescope work was possible; but on the 27th there was occasional clear sky, and some bright meteors were seen low down. Between 6.13 and 6.21 Dr. Copeland counted 109 meteors which could be referred to a common source in the direction of Andromeda, all moving slowly and of all degrees of brightness, from the second magnitude down to the faintest streaks. Occasionally one occurred fully of the first magnitude, leaving a train visible for 4 or 5 seconds. The meteors came now singly, now in pairs, and at times five or six at a time. Seven spectra were observed, all of the same character and somewhat faint. There was one relatively very bright line, but the position was not determined, though it was probably not far from F. The whole spectrum was like that of a bright nebula superposed on a faint continuous spectrum. One assistant observer noted 700 meteors between 7.10 and 7.20 in the E., and another 2000 in the S.W. between 6.30 and 7.30. In both cases the sky was half clouded over. From 8 o'clock to 8.30, favoured by a nearly clear sky, one of the observers noted 864 meteors again to the S.W. Shortly after 9 o'clock the display was fast vanishing, and about 10 o'clock rain-clouds settled down and concealed the sky.

Col. Tupman. The best observations for determining the period of the maximum appear to have been made at Glasgow by Prof. Grant and in Italy by Padre Denza. Padre Denza gave the number of observations every fifteen minutes from 6 o'clock until a little after 10 o'clock. From these it would appear that the maximum was between 6.15 and 7.15. The difference of longitude b about 36 minutes, this would be, in our time, between 5.40 6.40. Prof. Grant fixes the maximum about 6.35 or 6.45. E one seems to speak of them as chiefly of the second and third nitude, with occasionally a fine ball; as being nearly all white slow-moving, many of them leaving streaks, which lasted a short time. As to the determination of the radiant-points some careful observations were made by Mr. Denning at Bristol. observed the stream on four nights, and he saw a considerable e bition of Andromedes on Nov. 26th, getting 33, 126, 105, anc at different periods, a pretty rich shower. On the 27th he peared to have made most elaborate observations, and he sp very pointedly of the absence of radiation from a fixed cer The radiation was from a considerable area of seven degree diameter, although there were one or two points in that area w seemed to be more sharply defined than others. Mr. Den determined three radiant-points on the 26th, two on the 27th, on the 28th, and one on the 30th. He saw a considerable dis of Andromedes on the 30th, but on Dec. 1st, 2nd, and 3rd he unable to see any. The shower had absolutely passed away the night of the 30th. There was another point Mr. Den touched upon in his paper which was of very great interest. Andromeda meteors radiating from 27° +44° were all very sl in consequence of the meteors overtaking the Earth, so that the difference of their velocities formed the relative velocity, wl was about 12 miles per second. But Mr. Denning had seen showers having their radiant-points somewhere near that posit indicating that the meteors were also following the Earth; they were very swift meteors. The components of both stre he describes as very swift, which is a remarkable circumsta indicating hyperbolic motion; he states that he hopes to be to verify them next year. He (Col. Tupman) had the g fortune to witness this shower at Harrow, and determined radiant-points as carefully as he could; he afterwards calcula the orbit, which could be done absolutely independently, because interval of time between the shower on the 27th Nov., 1872, the 27th Nov., 1885, measured with precision two periods of volution. The corresponding mean distance was 3·4828, which assumed to be common for all radiant-points observed. The cen orbit came out exceedingly close to that of Biela's comet. He 245°·7 for the longitude of the ascending node; Biela's was 246 The longitude of the perihelion was 109°·2; Biela's 109°·6. inclination was 13°·6, Biela's 12°·6; excentricity ·7508, Bie ·7599. The perihelion distance was ·860, and Biela's ·861; ap lion distance 6·106, Biela's 6·191. The periodic time of meteors was a few days less than that of Biela's comet. Th were the main features of the papers.

Mr. Knobel. I am rather surprised at the small magnit ascribed to these meteors. With me the weather was not at all propitious; and although there was no first-magnitude star visible, I saw a great many meteors, and it seemed to me there was a much larger proportion of meteors brighter than first-magnitude stars than described in these papers. The general magnitude of the stars is supposed to be about the 2nd and 3rd. It is remarkable, watching as I was in apparently dense haze and cloud, not being able to see a star, yet I saw meteors flashing through in all directions. It shows they were very much brighter than the papers say.

Lord Crawford. I was in Gloucestershire at the time. I only saw the stars shooting for three minutes and not more, just through the haze. The only stars actually visible at the time were the "W" in Cassiopeia; and all the meteors I saw, perhaps forty or fifty, were not brighter at that time than the stars in the "W" in Cassiopeia. These were seen through a haze.

Mr. Common. I wish to draw attention to one point. I was observing the meteors with a field-glass for some time, and some of the brighter ones that left streaks behind visible to the eye for two or three seconds were visible in the field-glass for nearly a minute. They had a peculiar appearance, such as you see in De La Rue's vacuum discharges, like a row of coins slightly separated. Another thing that very much surprised me was, when the sky cleared between six and seven, and when there were not many meteors visible to the naked eye, there were a good many visible with the field-glass. When observing this display between 5.20 and 5.25 no first-magnitude stars were visible through the haze, and yet I saw behind this haze several bright meteors flash. From a quarter to six to seven o'clock, when the sky was less clouded, I counted them at the rate of twenty to thirty a minute, looking at one part of the heavens alone. The most noticeable feature was the number of small meteors that were seen, and with the aid of the telescope the great length of time that the trains of the large meteors lasted. I noted one about 6.45 that exploded over Cassiopeia, which was far beyond a first-magnitude star and more like Venus at her brightest.

Mr. Spitta. I saw one small meteor through my 10-inch, but I could not see any train at all. The large meteor you spoke of about 6.45 was very strong and lasted a long time.

Mr. Common. In the "W" of Cassiopeia?

Mr. Spitta. Yes, I saw that very one; but with regard to the small meteors I looked at for a very long time, I saw them pass across the field, but I could not see any train.

Mr. Ranyard. I should be inclined to concur with Mr. Knobel that there were many meteors larger than the first magnitude—some as bright as Venus. The thing that struck me most was the size of the radiant-area. I think it was elliptical, about 6° by 10°. At last it seemed that the meteors were approaching us in several directions differing by 5 or 6 degrees at least. It is difficult to believe there could be such a ring moving round the Sun. T would be so very distant from one another in part of their or It occurred to me it might be explained by the irregular sha of the meteors coming into the atmosphere, and that their mot in the atmosphere is not parallel to their motion outside atmosphere.

Admiral Sir E. Ommanney. In the Isle of Wight I made sc observations from 6.30 to 7.30, and what struck me chiefly was aspect of the zenith compared with that part where the most brilli display of the radiant meteors was in operation; that is to s immediately over my head there were almost instantaneous flas in such quick succession that it was hardly possible to count th but during the maximum display two meteors in Cassiopeia w remarkably brilliant, and some of the most brilliant meteors w displayed in the neighbourhood of Cassiopeia. I cannot say tha saw any meteors comparable to Venus or any star of the first m nitude. One remarkable feature I noticed was the erratic course the meteors; some of them passed from the north-east to the nor west, almost parallel to the horizon. One of these erratic mete described the longest course I noticed.

Col. Tupman. By which you mean not an Andromede?

Admiral Sir E. Ommanney. There was no connection with nor had the display in the zenith any radiant-point at all. Th seemed almost instantaneous and with very short tracks.

Mr. Spitta. Is any mention made in the papers of station meteors?

Col. Tupman. Mr. Denning has drawn a great many on chart.

Mr. Spitta. There was a great absence of them in 1872.

Admiral Sir E. Ommanney. I did not observe a single stationa meteor of any description, though it was a cloudless night. I referring to the 28th.

Col. Tupman. That was my experience.

Admiral Sir E. Ommanney. I watched on the following night most brilliant night it was) and I did not see one.

Mr. Ranyard. I saw four on the following night.

Mr. Knobel. I turned the telescope on the radiant-point, and saw some meteors glow out. I observed up to about 9 o'clock that evening.

Mr. Spitta. There was great attention called in 1872 to t extension as time wore on of the radiant-point. It commenc away from Cassiopeia, and then extended towards it. Hersch calls particular attention to it. I do not know whether ar observers made a note of it this year, but the area seemed to n quite elliptical. It will be interesting to know if that was see because the radiant-point has not been at all settled.

Col. Tupman said on that subject he might mention the radian points determined by Denza and Schiaparelli. They both g (and they must have observed independently) an increasin

R.A. and decreasing declination. The time of the first radiant was at 6.35, R.A. 15°, declination +45°; second radiant at 7.12, R.A. 18½°, declination +44°; third radiant at 8.7, R.A. 23°, declination +42°. That was a motion of 8 degrees in R.A., increasing and 3 degrees in declination. P. Denza's observation also gave three radiants: the first at 7.35, R.A. 22°, declination +44°; second at 8.20, R.A. 26°, declination +43°; third at 9.8, R.A. 28°, declination +42°. That was a motion of 6 degrees in R.A. and of 2 degrees in declination in something less than two hours. Those two sets of observations seemed to show a distinct motion of the radiant. [Black-board illustration.] It was very instructive when they thought of the meaning of there being a great many radiants surrounding the principal radiant; it meant that, all of these occurring at the same epoch, the meteors were all near together at the moment of encountering the Earth, but at every other part of their orbit they are far apart. That was in favour of the ejection theory started by an anonymous writer in 'The Times' the other day; but if they were ejected from the Earth millions of years ago, they must have suffered very little perturbation in the meantime, because they remained all together to this day.

Mr. Ranyard. It seems to me that the atmosphere interfering with their direction is the much more probable physical cause of the large radiant than the possibility that they were ejected from the Earth. One would think they would be ejected with some difference of velocity which would give a difference of time of revolution and they would not return together. After millions of years they would be drawn into very different orbits, and we could not expect them all to arrive together.

A vote of thanks was passed to the authors.

Mr. Knobel read a paper by the *Rev. S. J. Johnson* on an occultation of Uranus in December 1885.

Mr. Knobel. I should like to call attention to the observations on the magnitude of the Nova of Andromeda, made at the Radcliffe Observatory at Oxford. I apprehend that those observations were eye estimates, made with the telescope, as they differ very materially from the photometric determinations of the brightness of this star. I may mention the estimates at the Radcliffe Observatory of the brightness of this star as compared with photometric observations made by Prof. Pritchard at Oxford, and by Dr. Müller at Potsdam, viz.:—

	At Radcliffe.	Prof. Pritchard.	Dr. Müller.
Sept. 9	8·0	8·48	8·46
17	8·5	..	9·01
18	8·5	9·34	..
21	9·2	10·03	9·36
24	9·6	9·66	..

		At Radcliffe.	Prof. Pritchard.	Dr. Müller.
Sept.	25	9·5	9·85	..
	26	10·0	9·71	..
	30	10·7	9·69	..
Oct.	12	11·2	9·81	..
	13	..	..	10·04
	16	11·2	9·96	..

Further observations at the Radcliffe Observatory show a steady diminution of brightness down to the 10th December, when the magnitude was estimated at the 14th magnitude. The notes appended to the paper I can myself confirm, for the Nova was only just discernible while the nucleus of the nebulæ was distinctly visible.

Mr. Stone. I cannot offer any explanation of these discordances. I may say the observations were made with great care, and have been referred to one or two comparison stars, whose magnitudes are given. There is a small map with my paper giving the magnitude of the stars, by which the whole magnitude was estimated.

Mr. Knobel. They were, I suppose, direct eye estimates?

Mr. Stone. Yes, made in the ordinary way by comparison with stars in the neighbourhood, two of the stars in Argelander, and those being measured these were interpreted in the usual way.

Mr. Christie. Were precautions taken to eliminate the influence of the background of the bright nebulæ in these observations? because that is a very disturbing cause, both in the eye estimation and in the photometer.

Mr. Stone. There may be certain disturbances. These estimates of magnitude were referred to the stars of comparison. There are certain stars given in the chart; and these magnitudes are estimates with regard to the magnitude of those stars, and interpreted in that way; but the question of the background with regard to estimation is a serious question. It really comes to this: What is the correct standard of magnitude? Whether are you to estimate magnitude according to the eye, or according to the eye armed with the telescope, or without any extraneous absorbing medium? or whether is it to be the magnitude as seen through a wedge after light has been got rid of by the absorption of the wedge? The result may mean very different things, according to the circumstances under which the estimates are made. These are eye estimations referring to the single magnitude of certain stars in the neighbourhood.

Mr. Knobel. In these series of observations there is a difference of three whole magnitudes in the eye estimations, while with the photometric the difference is only 1½ magnitude.

Mr. Brett. Whose photometer was it?

Mr. Knobel. Dr. Müller's Zöllner photometer at Potsdam, and Prof. Pritchard's wedge at Oxford.

A Member. I do not think they use a wedge at Potsdam.

Lord Crawford. There is no photometer equal to that of Zöllner for workmanship or accuracy.

Mr. Christie. I think the point of interest in these eye estimations is to make out how the effect of the influence on the eye of the bright portion of the nebulæ immediately surrounding the star is separated from the influence on the eye of the star itself; because the danger in eye-estimates of this kind is that the eye would perhaps estimate the total effect of the star *plus* the portion of the nebulæ surrounding it, and it will compare with different effect with another star at a certain distance near a dark background. In the case of the comparison star, the background would not supplement the light of the star, and therefore I should expect considerable divergence *à priori* between eye-observations and photometric observations in such a case as that of the Nova in Andromeda.

Mr. Common. Is it not a fact that a dark background would make the star look brighter, and a light background would make the star look less bright?

Mr. Christie. Not on the hypothesis I am considering.

Mr. Common. With a high power and increase of the background you do not see the star.

Mr. Christie. I do not know to which class of observations Mr. Common is referring. Under certain circumstances it may be that the eye estimates the total effect of the star *plus* the part of the background immediately surrounding it, and compares that with the total effect of another star, which may have no visible background to supplement its light. But if you take photometric observations I think the conditions may be reversed. I think both classes of observations are liable to be affected by the background, and in opposite directions.

Mr. Brett. That is a remark applicable to either wedge- or eye-observations.

Mr. Common. They are all eye-observations, except the observations we are making now. [Laughter.]

Mr. Todd. In our estimations at Adelaide we observed the star diminish by three magnitudes, closely corresponding to Mr. Stone's results; but of course, in Adelaide, Andromeda would be low down, and therefore the observations were not made under the same circumstances as those at Oxford; but the eye-observations of my assistant at Adelaide closely correspond with the brightness found by Mr. Stone.

The President read a letter relating to the Elizabeth Thompson Science Fund, U.S.A., announcing that the fund intended to advance and prosecute scientific research now amounted to $25,000 and that applications for grants should be forwarded to Dr. C. S. Minot, 25 Mount Vernon Street, Boston, Mass., U.S.A.

Mr. Knobel. We have just received a rather important paper by *Prof. T. H. Safford*, on a comparison of Struve's right ascensions of Polar stars, from which I will read one clause:—"The Groombridge Catalogue of circumpolar stars is so important, and in many respects excellent, that its positions should be improved. attempt has been made to do this by the application of system corrections." And the concluding sentence is—"There is no dou we think, that Groombridge's work deserves nearly as much attention of future ages as does Bradley's, allowance being m for the limited region in which he laboured, and I am sure tha careful revision of his results would repay the trouble spent u it in a great variety of directions." [Hear, Hear!]

Col. Tupman. Several Fellows present have probably was many hours in sweeping for Barnard's Comet. If so, they will glad to know that a place has been sent by Dr. Copeland, of D Echt, as follows:—Time of observation Dec. $7^d\ 12^h\ 21^m\ 45^s$; R. $4^h\ 12^m\ 29^s{\cdot}07$; Decl. $+5^\circ\ 3'\ 52''{\cdot}9$.

The following papers were also announced:—

J. E. Gore. "On a suspected new Variable Star in Coro Borealis."

J. Tebbutt. "Observations of Double Stars at Windsor, N South Wales."

J. E. Gore. "On the Orbit of γ Coronæ Australis."

A. Marth. "Ephemeris for the Satellites of Uranus, 1886."

W. F. Denning. "General Catalogue of Radiant-points Shooting-Stars."

The following gentlemen were duly elected Fellows of t Society:—James Hunter, F.R.C.P.E., Walter C. Johnson, M.I.C. and Richard Wilding.

The Meeting adjourned at $9^h\ 35^m$ P.M.

The Liverpool Astronomical Society.

THE Third Meeting of the Session was held on Tuesday, Dec. 8t 1885, at the Association Hall, Mount Pleasant, the President, M Isaac Roberts, F.R.A.S., F.G.S., in the Chair. Five new Member were elected.

A paper by Mr. St. Q. Gage, was read on "Star Colours," whic is a continuation of a list of coloured stars that is now bein published in the Society's Journal. Mr. J. Rand Capron contri buted a paper called "Andromeda Meteors," in which he state that the display to which attention was drawn by circular fro Dun Echt took place on the 27th Nov., but earlier in the evenin than was anticipated. It commenced soon after dusk and laste till 9 P.M. At times the stars fell almost continuously, an occasionally 3 or 4 at a time. A few of the observations, whe the shower was thickest, gave 40 to 50 per minute. Except for short period only, there was always cloud and mist to some degre so that the countings and estimates are possibly under the mar The estimated proportion of large meteors was 1 in 10; these we white, with long yellow or reddish-yellow tails, and 3 or 4 times the size and brightness of Jupiter. A considerable proportion were referred to the radiant-point, but frequently they were scattered all over the sky, and not so easily traced.

Mr. R. C. Johnson expressed his surprise that they appeared so early in the evening, as we were led to suppose that they would not appear till later on. He had observed some himself on the 27th Nov. and also some on the following evening.

Rev. S. J. Johnson also contributed a paper entitled "Notes on the late Shower of Andromedes." He had counted 387 in 58 minutes, in breaks in the clouds; but this, he observes, could not have been above a fourth of the actual number. None remained visible more than 3 seconds and very few beyond 1 second. Frequently two or three passed across the sky simultaneously. No nearly stationary meteor appeared, but a radiant not far from γ Andromedæ would suit their paths.

A paper followed, by Mr. W. F. Denning, on "Meteor Shower near Cor. Caroli, Nov. 30 and Dec. 1 and 4, 1885." While observing the decline of the great display of Andromedes, Nov. 27, I noticed on Nov. 30 and Dec. 1 and 4 a few, very swift, long-pathed meteors directed from a radiant evidently near the northern horizon. These were brighter than the average and left narrow transient streaks along their courses. On the night of Dec. 4, I saw several additional meteors, which indicated a point at 194° $+43^\circ$, and may be regarded as fairly accurate. I believe this is one of the richest systems contemporary with the Andromedes. From observations at Greenwich on Nov. 13, 1870, Mr. Greg deduced a radiant at 193° $+40^\circ$, which falls suspiciously near the well-defined shower of the present year. This shower deserves special mention, as one likely to be often observed during future displays of the Andromedes and probably also of the Leonids.

The President observed that the weather on the continent having been fine, a very brilliant display took place on Nov. 27.

Mr. Edwin F. Sawyer, of Cambridgeport, Mass., U.S.A., sent a paper entitled "On a new Variable Star in the Constellation Vulpecula (D.M. $+27^\circ$ 3890)." It is a variable of the η Aquilæ type. The observations have not been numerous or continuous enough, owing to cloudy weather, to determine the period with certainty; but the period will not vary much from 4½ days, fluctuating from 5·5 to 6·7 magnitude. The position of the star is R.A. $20^{h}\ 45^{m}\ 19^{s}{\cdot}4$, Decl. $+27^\circ\ 42'{\cdot}3$. The star is not in Argelander's 'Uranometria Nova.' In Heis's Catalogue it is rated 6·0; Harvard photometric Catalogue 6·1, which is also the magnitude in the 'Durchmusterung.' The star is likely to prove an interesting one, owing to its short period, there being only three known variables of this type, with shorter periods.

The President observed that variables of such short periods suggest rotation on an axis. We generally consider these stars to be larger than our Sun, yet our Sun takes 26 days to rotate; so that, if such variables are larger than our Sun, it is possible they m have a dark side and a bright side. Spots upon their surfa would not cause the variation. Rev. J. H. Honeyburne suggest that a dark body might intervene between us and the star, regular periods, thus causing the variability.

Mr. Johnson observed that we are yet without any reliab variable-star theory.

The Wedge Photometer.

In the last issue of the 'Observatory,' the *précis* of an article i the 'Sidereal Messenger' for November is printed, wherein th author, Mr. Parkhurst, makes certain criticisms on the wedg photometer, as being affected, he says, by the luminosity of th background. As far as I can understand Mr. Parkhurst's remark he appears to me to be labouring under entirely erroneous conceptions. If I do not misapprehend the proper interpretation o his experiment, the conclusion to be drawn from it confirms precisely the very point for which I have all along contended. Henc I conceive that the simplest way of removing the erroneous impressions conveyed in Mr. Parkhurst's article will be to give a simpl and succinct account of what my photometer claims to effect And this I proceed to do.

1. The instrument which I use, when attached to a telescope o four inches aperture, extinguishes the light of a star of abou 8·75 magnitude at one inch from the thinner end.

2. At this point of the wedge it also extinguishes average moonlight, and of course at all other thicker parts.

3. It is important to remark that this extinction of ordinary moonlight or of daylight is experimentally very nearly independent of the aperture of the telescope, whether it be four inches or twelve inches.

4. At 4·6 inches from the thin end, Polaris is extinguished: mag. 2·05.

5. At 6·3 inches from the thinner extremity Sirius is extinguished, the magnitude of which is approximately two magnitudes brighter than the first magnitude.

6. Every additional 5·39 inches wedge interval extinguishes one magnitude additional.

7. The four-inch telescope itself renders just visible a star of the eleventh magnitude; and it is therefore to this eleventh magnitude approximately that every star is reduced, when it is said to be, or considered to be, extinguished by the wedge.

8. Average moonlight, being just extinguished at about one inch from the thin end, will exercise no influence on the point of extinction of any star brighter than the eighth magnitude. For fainter stars the photometer must be attached to a telescope exceeding four inches in aperture.

9. Where Polaris is extinguished, average moonlight is reduced to that of a fifteenth magnitude star, or to a four hundred and thirtieth of its original intensity. When Sirius is extinguished, the moonlight is diminished to a ten-thousandth part. But in any ordinary circumstances observations in moonlight may be avoided.

10. Mr. Parkhurst has himself shown, by an actual experiment, that if a star be rendered invisible, on account of moonlight, the extinction of any other star brighter than the former by 1·2 magnitude will not be affected by the background; this is the very point I contend for. Only the difference of magnitude might be considerably less than 1·2 mag.

11. The practical limit to the accuracy of the final determinations is about ·06 magnitude; roughly speaking, it is the tenth of a magnitude. C. Pritchard.

1885, Dec. 8.

The Andromeda Meteors.

The display to which attention was drawn by circular from Dun Echt took place on the 27th, but earlier in the evening than was anticipated. It commenced soon after dusk and lasted till 9 P.M., when clouds and rain prevented further observations. Ten time-records were taken at intervals at Guildown, and three other local ones have been communicated to me. At times the stars fell almost continuously, and occasionally three or four at a time. As the result of actual countings of portions of the sky, the estimated general rate for all parts was found to be as follows:—

	per min.
6 P.M.	10
7.20 „	22
7.50 „	29
8.30 „	25
9·0 „	26

A few of the observations, when the shower was thickest, gave 40 to 50 per minute.

Except for a short interval about 7.30, there was always cloud and mist to some degree, so that the countings and estimates are possibly under the mark. The estimated proportion of large meteors was 1 in 10. These were white with long yellow or reddish-yellow trails, and three to four times the size and brightness of Jupiter. The intermediate ones in size were also white. The smaller stars often appeared of a bluish, and some of a yellow or yellow-red tint. A considerable proportion of the meteors were referred to the radiant-point, but frequently they were scattered all over the sky, and not so easily traced. At intervals they seemed more numerous in particular quarters, notably E. and W., and two observers looking to different points would differ considerably in their countings. The numbers observed overhead did not see larger than elsewhere. At 9 P.M. on the 28th three large on were observed.

Table of Observations of Andromeda Meteors, November 27, 1885, at Guildown and two other places.*

Time.	State of weather.	Observer.	Time of Counting.	Number observed.	Direct
P.M.			minutes.		
6	Partly thick	C.	5	25	N.
6	Partly thick	L.	¼	5	N.
7	Much wind. Some seen through clouds.				
7.20	Clear	W.	1	11	S. & V
* 7.30	Clear	B¹.	10	74	N.E.
7.40	Clear. (10 larger ones in 67.)	P.	10	107	S. &
7.45	Clear	B².	1	25	N.
7.50	Clear	P.	5	73	S.
7.50	Clouded. (Included several large ones.) ...	C.	5	12	N.
8.0	Clearing, but part clouded	P.	10	68	N.E.
8.5	Part clouded	B².	1	25	E.
* 8.15	Part clouded	E. O.	1	20	?
8.30	Part clouded	P.	10	126	W.
9	Part clouded	C. & P.	5	65	W. &

Guildown, Nov. 28, 1885. J. RAND CAPRON.

Observations of Comet 1885 d *(Fabry), made at Mr. Wigglesworth's Observatory with the* 15·5-*inch Cooke Refractor.*

Date 1885.	Greenwich Mean Time.	Comet – Star. $\Delta\alpha$.	Comet – Star. $\Delta\delta$.	App. α Comet.	App. δ Comet.	N Co
Dec. 4,	$7^h\ 41^m\ 50^s$	$-1^m\ 50^s{\cdot}14$	$+8'\ 41''{\cdot}2$	$0^h\ 32^m\ 5^s{\cdot}96$	$+20°\ 57'\ 32''{\cdot}8$	10
5,	12 12 22	—1 0 ·41	—1 36 ·8	0 29 19 ·69	+20 55 32 ·6	9

Adopted Mean Places of Comparison Stars for 1885·0.

1885.	α.	Redn.	δ.	Redn.	Authority.
Dec. 4,	$0^h\ 33^m\ 52^s{\cdot}56$	$+3^s{\cdot}54$	$+20°\ 48'\ 27''{\cdot}1$	$+24''{\cdot}5$	$\text{B}-\text{W}_2\ 0^h\ \frac{838+840}{2}$
5,	0 30 16 ·59	+3 ·51	+20 56 44 ·7	+24 ·7	$\text{B}-\text{W}_2\ 0^h\ 738$

Remarks.—Dec. 4. The comet is round, faint, and about 1′ in diameter, the nucleus being about equal to a 12th mag. star.

The comparison star is the principal of an open double star.

Dec. 5. The comet has not perceptibly changed in brightness since yesterday.

The observations are not very easy, the faintness of the comet

rendering a feeble illumination of the wires necessary. In consequence of that the wires appear ill-defined, and great care is required to get them centrally over the comet; for the wire, where it is over the brighter part of the comet, becomes almost invisible for want of a dark background, while an increased illumination of the wires renders the comet nearly invisible. No such difficulty exists with the comparison star; if it is a bright one the wire appears dark on the small disk of the star, and if it is a faint one, the bright wire is seen without difficulty right across the star's image.

The first intelligence of the discovery was received here through a Dun-Echt Circular. J. GERH. LOHSE.

Mr. Wigglesworth's Observatory,
Scarborough, 1885, Dec. 9.

La grande pluie des étoiles filantes du 27 *novembre,* 1885, *en Italie.*

La pluie extraordinaire des étoiles filantes du 27 novembre, 1872, s'est renouvelée cette année le même jour et à peu près avec la même intensité. D'après les télégrammes et les relations que nous avons reçus en grand nombre jusqu'à présent il résulte que le phénomène en question a été remarqué dans toute l'Italie depuis les Alpes jusqu'à l'extrémité de la Sicile, et qu'il se produisit partout sous les mêmes formes. Il commença à la tombée du jour. A Tarente à 5^h du soir les étoiles jaillissaient et filaient en lignes si compactes, qu'elles perçaient de temps en temps l'obscurité déjà avancée de la nuit.

A Palerme quelques-uns de mes anciens élèves ingénieurs comptèrent 4600 météores de $5^h\ 15^m$ à $6^h\ 30^m$. A cette heure la pluie météorique se manifestait en plusieurs autres endroits avec une abondance tout à fait surprenante.

Dans notre Observatoire on commença à explorer le ciel à 6^h du soir (temps moyen de Rome). Nous avons suivi la même méthode que je suivis en 1872; les observations actuelles peuvent en conséquence être comparables avec celles d'alors. Comme j'eus déjà plusieurs fois l'occasion d'exposer cette méthode, je crois à propos de l'omettre ici. Je me bornerai à rapporter les résultats obtenus de 15 en 15 minutes, et afin de mieux éclaircir un relation, je vais donner ci-dessous un tableau dont la seconde colonne indique le nombre des observateurs chaque quart d'heure; et la troisième l'état de l'atmosphère en dixièmes de ciel libre. La quatrième colonne contient le nombre des météores réellement comptés, et la dernière le nombre supputé des étoiles c. à. d. le nombre qu'on aurait du avoir par conjecture si les observateurs eussent été toujours au nombre de quatre et que le ciel eût été toujours serein.

Durée de l'Observation.	Nombre des Observateurs.	Dixièmes de ciel découvert.	Nombre des météore	
			observé.	calculé.
6. 0– 6.15	2	10	2800	5600
6.15– 6·30	2	10	3100	6200
6.30– 6.45	2⅕	10	3400	6200
6.45– 7. 0	3	10	4500	6000
7. 0– 7.15	4	10	6200	6200
7.15– 7.30	4	7	3500	5000
7·30– 7.45	3½	7	3100	4900
7.45– 8. 0	4	7	3200	4600
8. 0– 8.15	4	7	3100	4400
8.15– 8.30	4	7	1700	2400
8.30– 8.45	4	6	1500	2500
8.45– 9. 0	4	5	1000	2000
9. 0– 9.15	4	5	800	1600
9.15– 9.30	4	4	600	1500
9.30– 9.45	4	4	500	1200
9.45–10. 0	3	3	234	1000
10. 0–10. 8	4	3	312	1010
Heures ..4^{h} 8^{m}.			39546	62300

Le ciel fut obscurci à 10^{h} 8^{m} par un épais brouillard, qui le dér à nos yeux tout le reste de la nuit. Ailleurs aussi de noires vape voilèrent le ciel à la même heure et même avant.

Seulement dans quelques localités de montagne et du midi, le ciel se conserva serein jusqu'à l'heure la plus reculée de la n on affirma d'un commun accord qu'à 11^{h} le phénomène ét presque fini. Les observations que nous avons faites dans deux soirées suivantes du 28 et du 29 nous conduisirent à résultat identique.

En 1872 nous en vîmes 33,000 dans l'espace de six heures ; cet fois-ci, quoique les observateurs ne fussent pas toujours au nomb de quatre comme à cette époque, nous en avons compté 39,0 En 1872 l'abondance des étoiles atteignit son maximum entre 45^{m} et 8^{h} 15^{m} ; cette année au contraire le maximum avait en dé son commencement, quand le phénomène prit à paraître, ainsi q le prouvent les nombres calculés à Moncalieri dans les deux pr mières heures, lesquels sont presque constants. Beaucoup o assuré que dès la nuit du 26 au 27 on vit une grande foule d météores sillonner les airs ; ici le ciel était chargé. Les observ tions des régions orientales répandront plus de lumière sur ce suje

En 1872 nous étions toujours au nombre de quatre observateu et nous comptâmes 18,600 étoiles tombantes pendant les de heures proches du maximum tandis que cette fois-ci dans le mê temps et presque toujours au nombre de deux ou de trois no *sommes* parvenus à la chiffre imposante de 29,500. Nous no hâtons cependant de dire que toutes ces chiffres ne donnent qu'une estimation approximative de l'apparition, puisque pendant ces deux heures on ne comptait guère chaque météore, mais les groupes des étoiles seulement (et pas même tous), qui se succédaient presque sans interruption.

Par conséquent les résultats obtenus dans ce temps ne représentent que la cinquième ou la sixième partie et peut-être sont-ils inférieurs au réel.

Je crois donc ne pas m'abuser en assurant que le nombre des étoiles apparues dans le temps de nos observations n'a pas été au-dessous de 150 à 160 mille. Le spectacle qui s'offrit à nos yeux pendant les deux premières heures du maximum était surprenant et tel qu'on trouverait de la peine à le décrire. De toutes les parties du ciel il pleuvait des masses d'étoiles semblables à des nuages cosmiques qui se fondaient. Elles étaient suivies de traces lumineuses et beaucoup de ces étoiles surpassaient celles de 1^{ere} grandeur ; quelques-unes même étaient de véritable bolides. La marche était en général lente et la couleur prédominant était le rouge tant à Moncalieri qu'ailleurs occasionnée par les nombreuses vapeurs éparses dans l'atmosphère. Les météores qui se trouvaient le plus près des régions irradiantes étaient très courts : aussi plusieurs n'étaient-ils que des points flamboyant par loi de prospective.

La plus grande partie jaillissait de la région même dont elles irradiaient en 1872 et laquelle se trouve entre Cassiopée, Persée et Andromède.

On ne distingait aucun centre secondaire comme dans des soirées ordinaires de la plus grande affluence.

Je mis tous mes soins à déterminer exclusivement la position du radiant, ce qui ne présentait aucune difficulté. Voilà de quelle manière je m'y pris. Je fixai attentivement sa position approximative, et en suite je traçai sur le papier le chemin de quelques-uns de ces météores qui se détachaient autour de ce point. J'achevai de cette façon 190 trajectoires, dont chacune à son tour en représente une infinité d'autres, qui suivaient le même chemin.

En partageant ces trajectoires en trois groupes j'ai obtenu les trois positions suivantes :

	Radiant.	
à $7^h\ 35^m$	$\alpha=21°$	$\delta=+44°$
8 20	$\alpha=26$	$\delta=+43$
9 8	$\alpha=28$	$\delta=+42$

Ces points sont compris entre ϕ et γ d'Andromède et le troisième point est tout près de cette dernière étoile.

Mon savant collègue M. Schiaparelli eut pour résultat :

	Radiant.	
à $6^h\ 35^m$	$\alpha=15°$	$\delta=+45°$
7 12	$\alpha=18{\cdot}5$	$\delta=+44$
8 7	$\alpha=23$	$\delta=+42$

En conclusion la grande quantité de météores observés de jours est la même que l'on vit en 1859 et en 1872 : elle se prése avec un intervalle de 13 ans qui correspond à la double péri de la comète Biela-Gambart, avec laquelle cet essaim météorique des relations immédiates.

De l'Observatoire de Moncalieri,
1885, décembre 5.

P. F. Denza

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*The Oxford Uranometria**.

About a year ago we had occasion to review the first part of great photometric work issued from the Harvard College Obs vatory, and now Prof. Pritchard's 'Uranometria' claims our att tion. That two of our leading observatories should have been th simultaneously carrying on a work of such dimensions as t determination of the magnitudes of all the lucid stars in t northern hemisphere, is convincing evidence that the question stellar photometry was felt to be one urgently requiring a co plete rehandling in the most skilful and thoroughly scienti manner possible. The searching criticism to which the 'Harva Photometry' and the papers Prof. Pritchard has already published the R.A.S. 'Memoirs' and 'Monthly Notices' have been expos has therefore been but the expression of an anxiety that t foundations of stellar photometry now being laid should be fi and trustworthy.

The form of photometer Prof. Pritchard has adopted is now t generally known to require description. It possesses the hi merits of simplicity of construction and use, and freedom fr liability to derangement. In addition to these qualities Pr Pritchard has been careful, in his use of it, to free it fr systematic errors arising from the continual use of the same p of the wedge for the same star. Not only has the coefficient absorption been separately determined for every point of t wedge, but the system of observation adopted has involved t employment of four different apertures of telescope in conjuncti with two wedges, and by two different observers. Each determ nation of magnitude therefore is the mean of 20 observations, set of 5 observations being taken with each of what are practical four different instruments. When to this is added the circu stance that the determinations of magnitude are differential onl and that therefore three complete sets of extinctions were made the standard star Polaris every evening, and that for the bett determination of the atmospheric absorption and of the magnitudes of southern stars, a considerable portion of the observations were made at Cairo, it becomes evident that the work of determining the magnitudes of nearly 3000 stars which Prof. Pritchard with his assistants Messrs. Plummer and Jenkins has here accomplished, is one of very considerable dimensions indeed.

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* Astronomical Observations made at the University Observatory, Oxfor under the direction of C. Pritchard, D.D., F.R.S., F.G.S., F.R.A.S., Savili Professor of Astronomy in Oxford.—No. II. Uranometria Nova Oxoniensis. Photometric Determination of the Magnitudes of all Stars visible to the Nak Eye from the Pole to Ten Degrees South of the Equator. Oxford: at t Clarendon Press.

The convenience of Prof. Pritchard's photometer, and the magnitude of the work he has undertaken with it, stand beyond dispute; but the delicacy of the wedge is another question. And here we are met with the circumstance that the observations seem to show little or no evidence of any effect due to changes in the sensitiveness of the observer's eye, to personality, to moonlight, and only to a small extent to colour in the star observed; and this unexpected and remarkable result has called forth not a little criticism, for as the construction of this photometer is not such as to lead us to expect that it would be wholly free from errors of these kinds, a doubt seems to be thrown upon its sensitiveness. Prof. Pritchard has replied to these criticisms in the frankest manner, showing that they had not escaped his notice; but whether he has quite refuted them is a point which we may, however, well think still *sub judice*. Probably the wise arrangement by which an ordinary evening's work is confined to three hours, or less, will largely explain the absence of deviations due to the first named cause, and with regard to the third it is most likely that observations on bright moonlight nights or of stars near the Moon have been generally avoided. The observations of Polaris which Prof. Pritchard has brought forward in this connection scarcely touch the real difficulty. The *substantial* accuracy of the Oxford star magnitudes is, however, shown by the close agreement which they bear to determinations made at other observatories and by widely different methods, and it is possible that the future may show that the exceedingly small deviations of the individual observations are a true index of the minuteness of their errors.

E. W. Maunder.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Great Nebula in Andromeda.

Gentlemen,—

While I must leave it to others to fully confirm the interesting and important photograph of this Nebula taken by Mr. Common in August last year, it may be worth while to publish the accompanying sketch of the Nebula as seen in a small telescope of four inches aperture, with a power of 200.

The sketch was made by noting all the small stars in the field of view seen steadily and distinctly, by identifying them in the woodcut of Mr. Common's photograph given in 'Nature,' vol. xxxii.

I cannot close without expressing the hope that such a pu cation, by English astronomers, may be found practicable. would certainly add to our knowledge of the stellar motions, be a proper mark of respect to the memory of a very excell English observer. Very faithfully yours,

Williamstown, Mass. T. H. Safford
1885, Dec. 2.

On the Effects of Commensurability of Mean Motions in a System.

Gentlemen,—

In the 'Observatory' for October, I see a note by Pı Asaph Hall on the supposed unstability of a system of two or m planets or satellites whose mean motions are commensurable. is commonly supposed, as Prof. Hall remarks, that such a syst must be unstable, and would be destroyed by mutual perturbatio Hence it has been held that this resulting unstability accounts the absence of bodies having mean motions commensurable wi those of Jupiter or Saturn.

This is quite a misunderstanding, founded on a mistaken ded tion from the ordinary expressions for the perturbations of a pla or satellite. It has arisen, I believe, in the following manner:–

In the ordinary solution of the differential equations, the pert bations are expressed in a series of terms of the form

$$\Sigma\,\mathrm{A}\sin(pt+\mathrm{N}),$$

where p is a function of the mean motions of n and n', and N function of the epochs, perihelia, and nodes regarded usually constants, whilst A is derived from a differential expression havi one of the forms

$$\frac{d}{dt}\,.\,\mathrm{A}\sin(pt+\mathrm{N})=+\mathrm{R}\,.\cos(pt+\mathrm{N}), \qquad \ldots\ldots$$

$$\left(\frac{d^2}{dt^2}+n^2\right)\mathrm{A}\sin(pt+\mathrm{N})=+\mathrm{R}\,.\sin(pt+\mathrm{N});$$

where R is a function of the masses, mean distances, eccentricitie &c., regarded as constant. Hence for any term A has one of t forms

$$\mathrm{A}=\frac{-\mathrm{R}}{p}$$

or $\qquad\ldots\ldots\ldots\ldots\qquad$ I

$$\mathrm{A}=\frac{-\mathrm{R}}{n^2-p^2}.$$

If, then, the mean motions n and n' are commensurable, an such that

$$\kappa n=\kappa' n',$$

there will arise terms of the form

$$\left.\begin{array}{l} A_1 \sin\{(\kappa n - \kappa' n')t + N_1\}, \\ A_2 \sin\{(n + \kappa n - \kappa' n')t + N_2\}, \end{array}\right\} \quad . \; . \; . \; . \; . \; . \quad \text{III.}$$

where, respectively,

$$p_1 = 0,$$

$$p_2 = n.$$

In these cases, one of the two forms of integrating factors becomes infinite, and the solution in the form II. fails. According to the ordinary method of treating such differential equations, under these conditions the expressions II. will take the forms

$$\left.\begin{array}{l} A_1 = R_1 t, \\ A_2 = \dfrac{1}{2n} R_2 t. \end{array}\right\} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad \text{IV.}$$

In both cases the resulting system becomes unstable.

It is this consideration, I believe, which has been held to prove the unstability of a system where the mean motions are commensurable.

There are two objections, at least, to this treatment of the differential expressions I. in the particular case of the commensurability of the mean motions. The first is the consideration that n, A, and t are not independent, as assumed to be the case in the transformation of II. into IV. The second and more important is the fact that the expressions I. are not rigid, but merely approximations which, whilst serving their purpose under ordinary conditions, fail in the special case supposed. The complete expressions are really of the form

$$\left.\begin{array}{l} \dfrac{d}{dt} \cdot A \sin(pt + N) = R \cos(pt + N) - a_1 \,.\, A \,.\cos(pt + N) \\ \left(\dfrac{d^2}{dt^2} + n^2\right) A \sin(pt + N) = R \sin(pt + N) - a_2 A \sin(pt + N) \end{array}\right\} \quad \text{I}'.$$

where a_1 a_2 are quantities of the same sign as p, and depending on the cube and higher powers of the disturbing forces.

Hence the exact forces of II. are

$$\left.\begin{array}{l} A = \dfrac{R}{p + a_2}, \\ A = \dfrac{R}{n^2 + a_2 - p^2}, \end{array}\right\} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad \text{II}'.$$

which, in the particular cases supposed, reduce to the forms

$$\left.\begin{aligned} A_1 &= \frac{R_1}{a_1}, \\ A_2 &= \frac{R_2}{a_2}, \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots \quad \text{III}'.$$

or ordinary forms of perturbation.

Hence the assumed unstability has no real existence.

There would be little real difficulty in proving that so far from any commensurability in the mean motions rendering a system of planets unstable, it is a condition of maximum stability, and that in a system where there was a near approach to such a condition the effect of the mutual perturbations would tend to render it exact.

EDMUND NEISON.

The Observatory, Natal,
1885, Nov. 9.

Saturn.

GENTLEMEN,—

The evening of Tuesday the 15th December was most favourable for observation. I examined Saturn with the full aperture of the 18-inch reflector and power 560. The markings of the outer ring were most clearly defined; there is no dark line indicative of division, but a band of shading rather nearer to the outer than its inner edge. The portion of the ball south of the equatoreal light had a very grey tone, and faint belts were visible at about latitude 50° S. The small light belt following the broad dark one next the equator, which was so evident in 1883, and less distinct in 1884, is now barely visible.

39 Circus Road,
St. John's Wood.

NATH. E. GREEN.

Meteors with Stationary Radiants.

GENTLEMEN,—

Correspondents have offered some objections to my theory on the above subject which appeared in your last number, and as similar objections have probably occurred to others of your readers, I ask a brief space for reply.

1st. Supposing that the meteors are travelling parallel to each other when they reach the atmosphere, it is said that owing to their different sizes, shapes, weights, &c., and the varying extent and density of the portion of the atmosphere traversed by them, their velocities in their original directions must be retarded in very different degrees; in consequence of which their tracks could not all pass through the same radiant-point. I admit the fact, and I think it explains why radiants differing by several degrees have been found by competent observers for meteors belonging to the same system. But this source of error affects meteors on the ordinary theory as much as on mine. Supposing that meteors do not partake in the motion of the atmosphere, their apparent displacement owing to the Earth's motion will depend on the relative velocities of the meteors and the Earth. But the meteors must be retarded in different degrees by the resistance of the atmosphere, owing to the circumstances already mentioned. Hence the relative velocities will be different and so will the displacements; and if the meteors are travelling in parallel orbits when they reach the outer limits of the atmosphere, they will not appear to pass through the same radiant-point after they have been differently retarded. But while the visible tracks of the meteors will not pass through a point on either theory, I do not see why they should not approach this point as closely on my theory as on the common one.

2nd. It has been remarked that if the ship did not keep up steam it would soon be simply carried down by the current instead of travelling in a path compounded of the two motions as I suppose. But in the case of the meteor there is no constant force urging it forward in its original path. True. The ship would be simply carried down by the current in the case supposed, because the resistance of the water to its motion would be very great. And in like manner, if we shut off steam when moving through still water the ship would very soon stop. But the resistance of the air to the passage of the meteor is very much less, and even when the meteor pursues the longest possible track through the air, the resistance is probably insufficient to produce more than a moderate retardation of the initial motion. A certain retardation, however, always takes place, and therefore the true path of the meteor during visibility will be somewhat nearer to the direction of the Earth's motion than the resultant of the original velocity and the Earth's velocity. But the difference I think is slight.

3rd. I think the motion of the atmosphere is fully impressed on the meteor at the moment that it first becomes visible, since it must have traversed a considerable depth of atmosphere before it is heated to luminosity. But when I speak of the motion of the atmosphere being fully impressed, I only mean that the full velocity of the atmosphere is compounded with the initial velocity of the meteor. The ship would probably run several yards into the current before the component of its motion in the direction of the current reached its maximum. In like manner the meteor no doubt rushes some distance through the attenuated air before the component of its motion in the direction of the air's motion attains its maximum. But I think this maximum velocity in the direction of the air's motion has been attained (or very nearly attained) when the meteor is first seen, and that the subsequent change in the direction of its motion is slight. At the same time the farther the meteor proceeds in its course (until it clears the atmosphere again, as it probably does in most instances) the more nearly the direction of its motion coincides with that of the Earth. The continued resistance of the atmosphere will produce this result even after the effects of the motion of the atmosphere have been exhausted.

It seems clear that the motion of the atmosphere must produce some effect on a meteor rushing through it. The question appears to be whether this effect is so small as to be inappreciable, or so large as to impress on the meteor a motion agreeing in velocity and direction with that of the Earth (in addition to the former velocity of the meteor). No intermediate theory will, I think, account for the facts.

Truly yours,
W. H. S. Monck.

Dublin, 1885, Dec. 15.

Relative Brilliancy of the Meteors in the Great Showers of November 27, 1872 *and* 1885.

Gentlemen,—

On November 27, 1872, the display of Andromedes was remarkable for the smallness of the meteors relatively to those observed in other streams, such as the Leonids and Perseids.

Of that shower Mr. E. J. Lowe said:—"The striking feature (more especially in the earlier portion of the display) was the extreme smallness of the great portion of the meteors, not one in ten being equal to a star of the third magnitude, and many were as minute as the smallest visible stars and might aptly be called *meteor dust*" ('Monthly Notices,' Dec. 1872, p. 81). Padre F. Denza at Moncalieri recorded that, out of an aggregate of 33,000 shooting-stars counted by his assistants, not more than about 20 were as brilliant as Jupiter or Venus. Padre A. Secchi at Rome mentioned 188 only, of 14,000, as equal to 1st mag. stars; and though Dr. Schmidt at Athens enumerated some 8000 meteors, not a single fireball appeared amongst them! At other stations the testimony was much the same—though the numerical strength of the shower was so very great there was a singular paucity of large meteors comparable to the bolides and fireballs frequently interspersed with the Leonids and Perseids and which give those displays, especially the former, an imposing effect which mere numbers can never attain.

But the Andromedes of November 27, 1885, were, as regards individual brilliancy, far superior to the shower of 1872, while they also probably excelled the latter in point of numbers. As the shower of 1885 progressed, fireballs occasionally appeared as bright as, or brighter than, Venus. Many were equal to Jupiter, and quite a large proportion were as conspicuous as first mag. stars. There were, perhaps, no fireballs of the very largest kind having sensible disks as much as ½° diameter and giving that vivid illumination of sky and landscape which are often the attributes of isolated fireballs. But though these were wanting in the display just witnessed, it yet exhibited many meteors of marked brilliancy, which was very far from being the case with its predecessor in 1872.

The latter I saw very imperfectly at Bristol with an extremely hazy sky, which quite clouded over after a brief observation in the early evening.

The conditions were somewhat better this year, and I managed to observe several thousands of the Andromedes before the rain and clouds interfered at about $6^h\ 40^m$. The display struck me as being one in which a very fair proportion of large meteors appeared, and that the descriptions applied to the shower of 1872 in regard to this feature would altogether fail to represent that of 1885.

The fact is confirmed by many other observers who have very kindly supplied me with their notes of the recent shower. Mr. J. R. Capron says:—"The estimated proportion of large meteors was 1 in 10. These were white with long yellow or reddish-yellow streaks, and 3 or 4 times the size and brightness of Jupiter." Col. M. F. Ward, writing from Partenkirchen, Bavaria, remarks:—"Some were very minute, hardly visible, others as large as Jupiter or Venus at their brightest. At first ($5^h\ 45^m$) counting the meteors was simply impossible, but at $6^h\ 25^m$ I reckoned 104 in one minute between the N. and N.W. points." Mr. P. Dudgeon, writing from Dumfries, says, "Many of the meteors were very brilliant, leaving trains of light lasting several seconds."

Many other correspondents express themselves to the same effect; and I note that a writer in the 'English Mechanic,' Dec. 11, 1885, p. 298, dating from Pornic, Loire Inférieure, states:—"In 1872 the meteors were all small, but very numerous. This time there were many as bright as Venus, but the number of the whole was less."

It is evident from all the facts that the display of 1885 was brighter than that of 1872 and it also appears to have been of considerably longer duration.

Yours faithfully,
W. F. Denning.

Bristol, 1885, Dec. 11.

Biela Meteors.

Gentlemen,—

In my 'Comets and Meteors,' the latter part of November 1892 is named as the date at which a shower of Biela meteors may be expected. Thinking it probable, however, that some outriders of the group might be seen on the night of the 26th or 27th of the present month, I kept watch for a short time on the former. Between $9^h\ 10^m$ and $9^h\ 25^m$ sixteen meteors radiated from a point a little north-west of *Gamma Andromedæ*, and at one time I counted five in three minutes. The next night was cloudy.

Yours faithfully,
Daniel Kirkwood.

Indiana University,
Bloomington, Indiana.
1885, Nov. 28.

NOTES.

REMARKABLE VARIABLE.—We learn from Dun Echt Circu No. 104, that Mr. J. E. Gore, on the evening of Dec. 13, foun reddish star, about 6 mag. and about 20′ following χ' Orio This object is not given by Harding, Lalande, Heis, or Birmingha and Mr. Gore suspects that it is either "a new star" or a rema able variable.

Drs. Copeland and Becker at Dun Echt found it on Dec. 16 be of $6\frac{1}{2}$ mag. and of an orange-red colour. It has a beauti banded spectrum of the 3rd type, seven dark bands being read distinguished. The bright intervals seem full of bright lines, es cially in the green and blue.

Its mean place for 1885 is:—R.A. $5^h\ 48^m\ 59^s$; Dec. $+20^\circ\ 9'$

β CYGNI, ALBIREO.—The December number of 'L'Astronomi contains an article on this star in which a singular mistake occu β Cygni is Flamsteed's 6 Cygni, and M. Flammarion has been mi led by this circumstance into identifying it with Bode's 6 Cyg which latter star Prof. Ball observed for annual parallax a year two back, and found for it a value of about half a second. Pr Ball's observations are referred to in the 'Observatory,' Vol. v pp. 334–336, and the distinction between the two 6 Cygni's is point out in a footnote. There is a misprint in the note, however, a for "Flamsteed's 6 Cygni is B of that constellation" should be rea "is β of that constellation." The star observed by Prof. Ball called 6 (B) Cygni, as being the second of the pair, 6 Cygni bein a double star.

SEARCH FOR THE TRANS-NEPTUNIAN PLANET.—In the 20th volum of the 'American Journal of Science,' page 225 *et seq.* Prof. D. Todd has given an account of his search, theoretical and practica for the trans-Neptunian planet. From November 1877 to Marc 1878 he was engaged in a telescopic scrutiny of the region to whic his theoretical researches had restricted him with the 26-inch re fractor of the Washington Observatory. Although this searc proved unsuccessful, Prof. Todd is by no means assured that th existence of the planet is merely fanciful, and thinks that the tim has come when this work can be profitably undertaken by a observer having the rare combination of time, enthusiasm, and th necessary apparatus. In the 'Proceedings of the American Aca demy of Arts and Sciences,' 1885, pp. 228–243, Prof. Todd ha published a list of all "suspected objects" which were noted b him during the telescopic search mentioned above, which will be useful not only to any astronomer who may take up this special work, but also to those engaged in researches on faint nebulæ and nebulous stars. The positions of these objects are explained by diagrams showing neighbouring stars, so that there ought to be no difficulty in an observer who is going over the ground again identifying them.

Bright Lines in Stellar Spectra.—It appears that the observation to which we referred in our note on the "Spectrum of the Great Nebula in Andromeda," p. 385 of the 'Observatory' for November 1885, was of the *Nova* as we had suspected, and not of the nebula. Mr. O. T. Sherman, the observer in question, has since published a couple of papers in the Amer. Journ. of Science, and has likewise communicated with us directly, and we learn that he has examined a great number of star-spectra, and in each case has found evidence of bright lines. Thus he finds that γ^2 Lyræ shows 9 bright lines, δ Cassiopeiæ 15, β Lyræ 18, γ Cassiopeiæ 19, ι Tauri about 20, γ Orionis 24, ξ Geminorum 26, and so with many other stars. These bright lines would seem at present to be most easily seen in the red stars; they also appear to vary in distinctness and intensity from time to time.

Mr. Sherman's account of his observations is a little lacking in clearness, and it is not so evident as could be wished, that he has not been deceived in them. At all events it will be wise to reserve a decision on the matter until further and stronger evidence has been supplied. The assertion that fifty stars taken at random each and all gave a spectrum with bright lines is too unexpected and important to be accepted, except upon the clearest evidence. We shall therefore look with great interest for further communications from Mr. Sherman and for confirmation or contradiction from other spectroscopic observers.

Cape Observations.—Mr. Gill has published, in one volume, the Cape Meridian Observations 1879 to 1881. During these years the Cape Transit Circle was employed in observing, in conjunction with Leiden, a list of fundamental stars required in the meridian observation of the stars between declination −1° and −20°, contained in Schönfeld's extension of the 'Durchmusterung.' In addition to these, two further lists of stars were observed, one of which had large Z.D. at the Cape and small Z.D. at Leiden, the stars of the other list culminating near the zenith of the Cape and at small altitudes at Leiden. There were also observed during these years stars which were employed in the longitude operations connecting Aden and the Cape.

Olbers' Periodical Comet.—Herr F. K. Ginzel has published, in 'Astronomische Nachrichten,' No. 2696, a sweeping Ephemeris of this comet during the months of January to October.

A New Minor Planet, No. 253, was discovered by Herr Palisa of Vienna on Nov. 12.

Minor Planet No. 249 has received the name of Ilsa, and No. 252 that of Clementina.

Elements and Ephemeris of Comet 1885 d (Fabry)[*].

A comet was discovered by M. Fabry at the Paris Observatory Dec. 1. It was reported to be a faint object with nucleus.

The following Elements and Ephemeris have been computed M. L. Schulhof from observations on Dec. 1 (Paris), on Dec (Paris and Algiers), and on Dec. 8 (Paris and Algiers) :—

T = 1886 March 30·2342 Paris M.T.

ω	129° 24′ 49″	Mean Eq. 1885·0.
☊	35 41 12	
i	75 46 56	

Log q = 9·76130.

Ephemeris for 12

1885.	α app. h m s	δ app. ° ′	Log Δ.	I.
Dec. 24	23 54 2	+20 42·1	0·1921	1·28
28	23 48 41	+20 46·3	0·1960	1·34
32	23 44 0	+20 53·6	0.1997	1·41

Lt.-Col. Tupman has found the error of the above ephemeris 1885 Dec. $23^d\ 5^h\ 45^m$ G.M.T. to be $\alpha - 10^s$, $\delta - 1'{\cdot}2$.

Elements and Ephemeris of Comet 1885 e (Barnard)[†].

On Dec. 3 a faint comet was discovered by Mr. Barnard of Nas ville, Tenn., U.S.A. The following Elements and Ephemeris ha been computed by Dr. J. v. Hepperger from observations on Dec. (Dresden), on Dec. 7 (Berlin, Leipzig, and Dun Echt), and c Dec. 10 (Vienna):—

T = 1885 May 12·3883 Berlin M.T.

π	183° 47′ 10″	Mean Eq. 1885·0.
☊	66 38 33	
i	92 47 51	

Log q = 9·73086.

The discordances of the middle place are $d\lambda \cos\beta = -3''$, $d\beta = -4$

These elements resemble those of Comet 1785 II.

Ephemeris for 12^h Berlin M.T.

1885.	α app. h m s	δ app. ° ′	Log Δ.	I.
Dec. 25	3 27 37	+7 11·4	0·2325	1·40
29	3 17 57	+7 47·0	0·2314	1·47
33	3 8 42	+8 24·7	0·2328	1·53

The brightness on Dec. 5, = 1.

NOTICE TO SUBSCRIBERS.

We regret that the publication of the "Companion" has bee unavoidably delayed. We trust that it will be in the hands of ou Subscribers very shortly after the appearance of the present numbe

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[*] Astron. Nachrichten, No. 2697.

[†] Ibid.

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E OBSERVATORY,

ONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
f the Royal Astronomical Society on January 8, 1886 81
f the Liverpool Astronomical Society 91

—

lescopes v. Small. By Prof. C. A. Young, Ph.D., For. Assoc. R.A.S. 92
ions of Nova Andromedæ. By Joseph Baxendell, F.R.S., F.R.A.S. 94
r-shower of Nov. 26–29, 1885. By Edwin F. Sawyer 95
mosphere in 1885. By the Rev. S. J. Perry, F.R.S., F.R.A.S. 97

ndence:—
d Maps for tracing Meteor-paths. By T. W. Backhouse, F.R.A.S. 98
d Change in the Astronomical Day. By Sir Robert S. Ball, LL.D.,
al Astronomer of Ireland 100
oric Shower of Nov. 27. By H. J. Bell, F.R.A.S. 100
iable Star η Argûs. By W. T. Lynn, B.A., F.R.A.S. 101
ion-Cycle. By the Rev. S. J. Johnson, F.R.A.S. 102
s of Jupiter. By Edmund J. Spitta, F.R.A.S. 102
with Shifting Radiants. By W. H. S. Monck 103
X. By W. H. Wesley 104

Method of Determining the Amount of Astronomical Refraction.—
Pulkowa Observatory.—The Great Pulkowa Refractor.—Newton and
News.—Astronomical Prizes of the Académie des Sciences.—The
ble Star ρ Eridani.—New Observatory in Indiana.—Effect on the
th's Motion produced by small Bodies passing near it.—Method of
porting a Mercury-trough for Reflection-Observations.—The late
J. C. Draper.—The R.A.S. Council.—Editorial Notes 105–111

nd Ephemeris for Comet Brooks 2. By Dr. H. Oppenheim 111
for Comet Fabry. By Dr. H. Oppenheim 112
nd Ephemeris for Comet Barnard. By Dr. A. Krueger 112

ommunications should be addressed to the EDITORS of the 'Observatory,' Royal Observatory, Greenwich, S.E.

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THE OBSERVATORY

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and T. Lewis, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverp
nomical Societies; Articles by various eminent Astronomers,
American, and Continental; Correspondence on topics of interest
with the Science; Notes on the progress of Astronomy; Reviews
nomical publications; Ephemerides of comets, variable stars,
satellites, and for physical observations of the Sun, Jupiter, &c.
the usual astronomical information.

Amongst the contributors to 'The Observatory' in 1885 were
Asaph Hall, Holden, Hough, Pickering, Pritchard, and You
Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs.
Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"
Astronomique (organ of the Paris Observatory).

CONTENTS OF No. 106.

Meeting of the Royal Astronomical Society on December 11, 1885 ....
Meeting of the Liverpool Astronomical Society ....

Articles:—

The Wedge Photometer. By the Rev. Prof. C. Pritchard, F.R.S. ....
The Andromeda Meteors. By J. Rand Capron, F.R.A.S. ....
Observations of Comet 1885 *d* (Fabry), made at Mr. Wigglesworth's Ob
vatory with the 15·5-inch Cooke Refractor. By Dr. J. Gerh. Lohse
La grande pluie des étoiles filantes du 27 novembre, 1885, en Italie,
Father P. F. Denza..
The Oxford Uranometria. By E. W. Maunder, F.R.A.S. ....

Correspondence:—

The Great Nebula in Andromeda. By Maxwell Hall, M.A., F.R.A.S...
Groombridge's Right Ascensions. By Prof. T. H. Safford, For. Ass
R.A.S. ....
On the Effects of Commensurability of Mean Motions in a System.
Edmund Neison, F.R.A.S. ....
Saturn. By Nath E. Green, F.R.A.S. ....
Meteors with Stationary Radiants. By W. H. S. Monck, M.A...............
Relative Brilliancy of the Meteors in the Great Showers of November
1872 and 1885. By W. F. Denning, F.R.A.S. ....
Biela Meteors. By Prof. Daniel Kirkwood ....

Notes:—

Remarkable Variable.—β Cygni, Albireo.—Search for the Trans-Neptuni
Planet.—Bright Lines in Stellar Spectra.—Cape Observations.—Olber
Periodical Comet.—Minor Planets ....

Elements and Ephemeris of Comet 1885 d (Fabry) ....
Elements and Ephemeris of Comet 1885 e (Barnard) ....
Notice to Subscribers...

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 107. FEBRUARY. 1886.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, January 8, 1886.

E. Dunkin, F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel and
Lieut.-Col. G. L. Tupman.

The Minutes of the previous Meeting were read and confirmed.

Col. Tupman reported that 54 presents had been received since the last Meeting, including a batch of photographs from Paris well deserving attention, and which would be mentioned afterwards.

The thanks of the Meeting were voted to the donors.

Capt. Noble asked whether the Secretary could inform him if Dr. Collett, of Leicester, was a Member of the Society. A person of that name was advertising himself as M.D., F.R.A.S., and he was giving testimonials to an American oil.

Mr. Knobel announced officially that there was no name of Collett in the Society's list for June 1885.

After some discussion *Capt. Noble* proposed "That an advertisement having appeared in several papers containing testimonials to the virtues of an American oil by a person described as — Collett, M.D., F.R.A.S., and as no person of that name is or has been a Fellow of the Royal Astronomical Society, the Secretary be instructed to take such steps as may be necessary to proclaim the fact that Mr. Collett has no connection whatever with the Society."

Admiral Sir E. Ommanney seconded the motion, which was then put and carried.

Several Fellows were formally admitted by "proxy" into the Society. Amongst them were several well-known names. After the conclusion of the ceremony,

Mr. Ranyard, who had been chosen by them all to act as "proxy," remarked that in his opinion the form was not absolutely or at all necessary to enable Fellows *to vote at the Meetings*. Further remarks were stopped by the President ruling Mr. Ranyard "out of order."

Capt. Noble could not see the necessity of the form.

Mr. Roberts (President of the Liverpool Astronomical Society). A letter from Admiral Mouchez, published in the 'Monthly Notices' for November, shows the necessity of making known what has already been done in mapping the stars. In 1883 I made experiments in photographing stars with ordinary lenses varying between $\frac{3}{8}$ of an inch and 5 inches in aperture, the lenses being made by English, French, and American opticians. One by Lerebour of 2 inches aperture gave the best results, and I adopted it as a standard for comparing the others. The comparisons were made by attaching two cameras to my 7-inch equatoreally-mounted refractor by Cook, and taking photographs of some well-known groups of stars under precisely the same conditions. The plates were selected with regard to uniformity, and sometimes a plate would be cut in two, a half being exposed in each camera. The result of these experiments and of comparison with Mr. Common's photograph of the Nebula in Orion was the adoption of a 20-inch reflector for stellar photography. The suggestion of Admiral Mouchez to allow an exposure of from 1 to 3 hours would make the progress of the work extremely slow. 15 minutes' exposure in a clear sky can often be obtained, but an exposure of 3 hours' duration would be rarely possible. Stars of small magnitude can be photographed by my reflector in 15 minutes, but it would be misleading to name photographic magnitudes by the side of those which have been determined by eye-observations until comparisons have been made between a large number of stars, and errors in focussing, sensitiveness of plates, duration of exposure, varying actinism, moisture, and density of image in development had been eliminated or reduced to a constant factor. As an illustration of this I have on the board disks showing the result of photographing Polaris when near the upper meridian between Sept. 15 and Dec. 15. Seventeen photographs have been taken with varying exposures from 1 second to 32 minutes. On some of them the companion was photographed faintly in 4 seconds, while in others it does not appear in 1 minute. On one plate it does not appear with an exposure of 16 minutes. It is therefore evident that the interpretation of photographs as regards star-colour and magnitude should be done under a due sense of the difficulties I have alluded to. I give in the paper a record of the photographs I have taken from the pole down to 69° decl., exceeding two hundred in number. How these negatives are to be used for astronomical purposes is a question constantly pressing on me, and the difficulties of which can be realized only by those who have fully considered it. I may enumerate some of the difficulties. Most of the plates have small specks on the film, many of which look like stars and are difficult to distinguish from stars even when viewed through the microscope. Dr. Gill, at the Cape, meets this difficulty by taking two photographs successively of the same field, giving each an exposure of one hour; but this makes the work almost Herculean. Another plan is to let the telescope run a few seconds of arc in right ascension during the exposure of the plate. Admiral Mouchez suggests three exposures of one hour each, making a triangular figure with three positions of one star. But the objection to this is that it will cause confusion in close stars; the disks of some will overlap others, leaving the dirt-specks still competing for recognition as stars. The long exposure of the plates adds to the difficulty in discriminating between specks and stars by making the star-disks appear black to the margins, while the short exposure makes some of the star-disks show fainter, and the atmospheric glare forms a halo round the star, which, under the microscope, materially assists in distinguishing between stars and specks. All stars below the 7th magnitude require a microscope to show them; but there is no difficulty in manipulating the light on the plate so as to distinguish with certainty stars from specks. This statement does not apply to printing direct from the negatives, which must be done in some form before star-photography can be appreciated generally and utilized as an astronomical pursuit.

It is a work of the first importance to secure good photographs of all stars down to the smallest magnitude in as short a time as possible, because they will be available in future time for comparison with photographs which can be taken at leisure by large instruments for special researches. The chart on which I am engaged will be twice the size of Argelander's, and with an exposure of 15 minutes for each plate will contain a much larger number of stars than are shown in his Atlas. I submit a few negatives as samples of those already taken. Among these are plates of Polaris, Andromeda with the Nova, the Pleiades, and the Nebula of Orion. The question of long exposure arises with regard to the disks of Polaris which I have placed on the board, and to which I have referred already, as showing that long exposures obliterate some close faint stars; and it will be necessary to regulate the exposure in such a way as regards time that a bright star may not extinguish a faint star. By comparing a rough drawing of the photograph of the Pleiades with Mr. Hall's map published in the 'Monthly Notices,' vol. xl., there are perceptible differences in the size of the disks and in the number of the stars shown.

The photograph of the Nebula in Orion shows nearly as much detail as Mr. Common's large photograph; but the faintest stars on Mr. Common's photograph are not shown, but those down to within one or two magnitudes of the faintest are photographed on the plate. I found the Andromeda nebula a difficult matter, as the actinism of the nebula is not at all like that in Orion; but after 16 minutes' exposure a trace of the centre of the nebula may be seen and also the new star distinct from the nucleus. With exposures of 32 minutes, 60 minutes, and 90 minutes the differences are still more clear.

Mr. Knobel. Perhaps it might be convenient to take another

subject of a similar nature before the discussion on Mr. Roberts
paper. We have received a letter from Messrs. Henry, of Par
Observatory, on stellar photography. They write from Pari
5th January:—“We have recognized, by means of photograph
the existence of a new nebula in the Pleiades. This nebula is
the neighbourhood of the star Maia, which it surrounds in pa
and where it appears in the photographs to emerge from it.”
comes out on one side. “This assumes a very characteristic spir
form, and extends to about two or three minutes of arc. It ha
been possible to obtain an image of the nebula on three differe
photographs, on 16th November and 8th and 9th December. W
add also that, up to the present time, we have not been able to se
the nebula in our telescopes. We have the honour also to sen
you an enlarged reproduction of the original negative showing th
nebula with surrounding stars. We are also permitted to sen
you some images of Saturn obtained lately.” I would desire
call your particular attention to these photographs, not only th
first one mentioned of the portion of the Pleiades, which show
very remarkable projections of the nebula surrounding the sta
Maia, obtained after three hours' exposure, but also to the ver
wonderful photographs of the planet Saturn, showing the inne
and the outer ring and the difference of the relative brightness
those rings, the crape ring undoubtedly, and Ball's division; als
the belts of the planet and the very dark polar cap of the plane
Some of the photographs are enlarged eleven times from the origin
negatives, and some of them forty-four times, and they are cer
tainly some of the most marvellous photographs that have yet bee
produced of celestial objects.

Mr. Ranyard. I should like to express my very great admira
tion for the photographs of the Bros. Henry. The detail of th
ball of the planet is exquisite. There is the band that so many
us saw a few years ago. The lighter band and the dark ban
below the polar cap are most delicately and beautifully shown, an
yet some of the sharper parts of the planet are not shown. Fo
example, in several of the photographs the great Cassini divisio
which is a marked feature of the planet, is only a dusky faint lin
and not as clear as the dark belt across the planet. The dark belt is n
doubt a little broader than the Cassini division, which through its ex
treme sharpness and blackness attracts the eye. The outer divisio
is of course entirely lost. With regard to the beautiful photograph o
the nebula of the Pleiades, Mr. Wesley showed me the old pictur
taken by Mr. Rutherfurd many years ago. It was taken with
wet plate and it does not show quite so many stars as this group
but it shows a great number, and there is no trace of the nebula
which is a very remarkable one, having a distinct spiral form.
look upon it as a most interesting discovery.

Col. Tupman. I should like to ask Mr. Roberts whether he ha
any special means of pointing his telescope during exposure i
order to correct the erroneous driving of the clock.

Mr. Roberts. As I am photographing in the neighbourhood of the pole my driving-clock is sufficiently good, and there is no necessity to watch or correct it. Mr. Grubb has in hand for me a more perfect method of driving the instrument when I require it at some distance from the pole.

Col. Tupman. Then I understand you contemplate always depending on the clock?

Mr. Roberts. When the exposure is longer than 15 minutes doubtless it would be necessary to watch; but with an exposure of 15 minutes only I have great hopes that a clock will be obtained sufficiently accurate.

Mr. Lecky. There is a very beautiful illustration of the photographic telescope in Paris in 'La Nature.' It appeared about three months ago. I saw it the other day, but had not time to read the description. The observer is looking through an attached telescope, and he has a rod in his hand, evidently for the purpose of correcting any error in the driving of the telescope.

Mr. Knobel. I think we ought to be very glad indeed that Admiral Mouchez's letter has brought forth some fruit in this country in the labours of Mr. Roberts. (Hear, hear!) I had very great hope that it might catch the sight of some earnest amateur who would devote himself to further the scheme; and I think it is a matter for congratulation that Mr. Roberts has determined to devote himself, his skill, his instruments, and his observatory to the interest of the scheme suggested by Admiral Mouchez.

Mr. Green. As the planet Saturn is in the discussion, I might refer to a most wonderful view I had of the planet on the evening of the 15th Dec. last. The air was in a remarkably steady state, and it enabled me to look on the exterior ring under a power of 500 or 600 with as much certainty of definition as though it was an engraving on paper. I felt no doubt whatever at the time about the absence of any definite dark mark. The part which I had seen previously, and which I called the shading, was there indeed. A clear and brilliant light followed the division which is usually called Cassini's; then this shaded band, commencing about halfway on the ring and extending outwards to the bright edge of the exterior ring next the sky. The interest attaching to the observation might also be shown in the evidence of belts on the planet at about latitude 50°, more delicate objects than I had seen before; and yet at the same time there was some comfort in the view, as it confirmed the doubtful observations of previous occasions. We are often very much in doubt when the air is not steady whether such and such things have been seen; but whenever on more favourable occasions I have been able to look steadily, I find I have seldom been mistaken in the previous view—showing that occasional glimpses are not mistakes, for we confirm them afterwards and prove them to be correct.

Mr. Common. I should like to express my great admiration of these photographs of the Brothers *Henry. I think* they are the most marvellous we have seen. These alone will show the immense importance that photography will have in the future. I took photographs of Saturn in 1879, when the ring was a line across the planet, with an 18-inch telescope and with a 36-inch; last week I had to enlarge some of these little ones, and was struck with the wonderful amount of detail visible even in those. I was thinking then that you can compare the early photographs of Saturn with what will be soon taken as we have compared the early photographs of the Moon with those that have been taken since. I believe that by experience and by proper methods we shall be able to get more planetary detail of Saturn, Jupiter, and Mars. I think that if the Brothers Henry will apply an enlarging-lens to the telescope they have to enlarge the primary image, giving longer exposure to make up for it, they might get such detail as it would be impossible to show now. There may be difficulties in the way, but I think this is a very good omen for the future, and I hope Messrs. Henry will produce even more surprising things. On certain occasions many of you have felt, no doubt, when you have been playing a game that nearly all men play at, and made a specially good hit, that no one is more surprised than the striker. That must have been the feeling of the Brothers Henry when they saw their photographs of Saturn, because the actual image of Saturn is not more than the 30th of an inch long, while the image of Jupiter in my telescope is less than one 25th. That bears enlarging to an inch lineal, *i. e.* 25 times. The original enlarging telescope is something like 20: so that you have an enlarging over the eye of something like 400 diameters, and by throwing it on the screen you can get an enlargement that runs into thousands, and yet retain the original formation. In these photographs there is no mistaking Jupiter. To my eye it is as plain as the large photographs on the wall here. If we can do that, then we have only to get an improved definition and enlarge the primary image—because you can get rid of the defects of the plate by increasing the exposure, and you will get better results than any hand drawing. In speaking of these photographs of the Brothers Henry, of course it is hardly necessary to say that they have gone further than anybody else to show that we are now making a new departure in astronomy. I will not say that the observer will be obsolete, but perhaps his functions will be entirely altered. Of course in these star-maps you must follow the same line as in photographing the nebulæ. Up to the present time we have not the power of putting on the plate large and small stars together, and for many reasons it is well we have not; but in taking photographs of the various parts of the heavens it will be just as necessary to have short exposures for the large stars and longer exposures for the small stars, and collate the two together as one picture. With regard to the very interesting paper by Mr. Roberts, there is a very great deal in it that I can thoroughly appreciate, because it agrees so well with what I have done and said myself; but there is an absence of particulars with regard to actual detail that I rather regret. I should like to have had a little more about the actual process. I do not quite agree with Mr. Roberts as to the difficulty that the specks on the plates will cause. I believe it is possible to obtain plates which shall be, for all practical purposes, free from specks, and so get rid of what he considers a very great trouble. In all cases duplicate plates must be taken. That is better than taking two images of the star on the same plate. I was delighted to see the photograph of the Pleiades; also of the Orion Nebula. When I wrote an article in 'Nature' in November 1884, I gave the result of some experiments with the telescope, using a second reflection from the mirror nearly half the size of the large one, throwing the image back behind the mirror. With an exposure of half an hour I got a very similar picture to that which Mr. Roberts exhibits, but smaller because the focal length of the mirrors happened to be 48 or 49 inches; and a lens of 48 or 49 inches gives a scale nearly exactly that of Argelander's maps. With the same reflector I happened to have screwed the small mirror in such a way that it had a slight motion to and fro. The result of the motion was lines, not points. By putting the photographs on Argelander's maps every line crossed a dot. It made a Greek *phi* of nearly every star. I do not know whether, in doubtful cases, some such photographs would not be as useful as dots, and balance a little systematic error in the clock if it does not exceed a small amount. Photographs of stars could not possibly be mistaken for specks. The distortion at the edges of the photographs is very small considering that the reflector was 20 inches aperture and 100 inches focal length. It says a great deal for Mr. Grubb's work. In regard to Mr. Roberts getting photographs without absolute control of the clock, I wish him success; but I am afraid he is trusting too much to the skill of the mechanic, because it is a thing that is almost impossible, and the only way to do it is to watch the image which is produced by the mirror as I did, or to do as the Brothers Henry did in Paris. From their description, and from what I gathered from what Mr. Lecky said, they have two telescopes fastened together, and there is no question of any declination axis between the two that might give a slight twist. The two are intimately fastened together, and one cannot move without the other. Messrs. Henry used a 13-inch object-glass for their photograph and an 11-inch object-glass for their visual work, and by having a high power and delicate means of adjustment they can keep the telescope going to a fraction of a second, and they have only to supplement the work of an excellent clock. I fancy Mr. Roberts will find he will have to devise some means of watching the exposure during the time it takes place, and not to trust to the clock alone. Even if you work on the meridian or nearly so, the refraction itself with long exposures will come in in a most objectionable way; but I wish him every success in the work he has begun. *(Hear, hear!)*

Mr. Ranyard. As to Mr. Common's suggestions about
creasing the diameter of the planet before it is photographed
have made a small step in that direction. I tried to take pho
graphs of Saturn, and also of Jupiter, with an enlargement of f
diameters, and they were not nearly so successful as those tak
in the primary focus. Of course with five diameters you requ
25 times the exposure to produce the same density, and in
times the exposure there are all the difficulties in driving owi
to atmospherical difficulties, as well as those of achromatism w
the enlarged lens, which are great. With the photographs tak
in a secondary focus one is able easily to see the great difference
brightness in the different parts of the ring, but nothing like t
detail you can see in the primary focus.

Mr. Roberts, in reply, said :—The criticisms have been of a ve
kindly character, and Mr. Common, who is a very great authori
on the subject, has spoken in a manner that is most agreeab
The possibility of obtaining plates free from specks of course
are always looking forward to, and we must hope that some mak
unless we ourselves succeed in doing so, may produce plates fr
from specks; but I did not find them, under the conditions that
am working with, any serious drawback after all. I may ventu
to say that I can distinguish between a star and a speck on a
of my plates within one in a hundred. I have means of checki
the clock. One is a finder attached to the reflector with a le
of 2½ inches in diameter, and in the eyepiece wires with di
tances between them, so that I can move them in the field
view and place a star between the wires and keep it there, if
think it necessary; and I have also a 7-inch refractor at the oth
end of the declination-axis that can be used for the same purpos
but as I am now photographing in the neighbourhood of the po
the clock drives the telescope with sufficient accuracy. As
centering the mirror, I hit upon a method of doing that whi
may be useful to any Fellows who may hereafter adopt it for
similar purpose. The mirror has a hole in the centre, so that
can look through at the image which is seen at the other end
the tube. By placing a glass reflector with a cross marked on i
instead of the photographic plate, and holding a light behind i
the cross and its reflected image from the mirror can be seen an
readily be made to coincide, when collimation is adjusted, and thu
I am able in a minute or two to place the mirror parallel wit
the photographic plate. I tried many ways before finding th
to be the readiest and giving as great an accuracy as the pla
devised by Dr. Stoney for reflecting the image of an electr
spark from the eyepiece to the mirror and back again.

The President. I think you will all agree with me that we ar
very pleased to have had the opportunity of hearing Mr. Robert
whose name is not unknown to us. He resides at a long distanc
from London, and we most heartily welcome him here, particularl
when he brings such beautiful photographs for our admiratio

With regard to the photographs of Messrs. Henry, I quite agree with Mr. Common that they are most beautiful, and I think they are really an advance which we could hardly have anticipated a year ago. Mr. Common has told us that all the details are shown in these photographs better than in any drawing. Therefore I am sure you will return your thanks to Messrs. Henry and Roberts. (Applause.)

Mr. Turner. Some time ago Mr. Marth described, in the 'Monthly Notices,' a very interesting method of graphically representing the solar system by means of curves corresponding to the orbits of planets and comets, which he called "intersects," and he gave some drawings in the 'Monthly Notices.' It struck me that these curves had some interesting geometrical properties. I worked out the equation of the curves and found it to consist of a relation of the second order between the distance of the point from the Sun and an ordinate. It struck me that the curves may be transformed, and by a simple kind of distortion they look more familiar. We then get the form of an ellipse corresponding to each orbit; in the case of the comets the curves would assume the parabolic shape. These curves are more familiar and their properties better known than those given by Mr. Marth, in which several things are not so readily recognizable as in a diagram of ellipses. (Mr. Turner explained his method on the blackboard.)

In reply to Mr. Glaisher,

Mr. Turner said he had written out the expressions for the centre, and position and magnitude of the axes, in terms of the elements of the orbit.

Mr. Glaisher. My point is that Mr. Marth's method is distinctly prettier ideally, because it comes closer to the actual physical facts and has nothing empirical about it.

Mr. Turner. Exactly.

Mr. Knobel then read two papers on a new variable star in Orion, one by *Mr. J. E. Gore* and the other by *Dr. Copeland.* The latter paper described the spectrum of the star as showing a spectrum of bright bands superposed on a strongly marked stellar spectrum of the third type. The bright bands corresponded to those seen in the spectrum of a hydrocarbon gas-flame and in the spectra of comets.

Capt. Noble. I observed this star last night, as no doubt many others did, and certainly it has degraded in light since I first looked at it. I had no means of actual photometry; mine is mere eye estimation; but it certainly has degraded in light, and is getting fainter. I have always seen this star yellow. They say it is orange colour. I think there is much personal idiosyncrasy. I hear of wonderful red stars, but when I look at them I find they are only rather a full yellow. I know when Mr. Chambers was writing his 'Descriptive Astronomy' we went over many which had been described as red, but we could see nothing in the deepest of them but yellow. I thought it was quite so full a yellow last night as when I first saw it.

Mr. Maunder. I observed the spectrum of this star on two oc sions. I certainly cannot add anything to that we have heard fr Dr. Copeland. Indeed, I have not seen so much as he has; I v simply able to recognize it as an exceedingly fine specimen Secchi's third type. The dark bands were exceedingly dark, a the bright interspaces remarkably bright; I do not know any s of the type in which the contrasts are so strong, but I was not a to notice any bright lines or anything I could reasonably susp to be a bright line. I measured the position of the sharp da edge of the principal band, and I got the position as 5169 ten metres. I do not know how that compares with Dr. Copela With regard to the colour of the star, I should certainly have d scribed it as a reddish star. The light seemed to me to be co siderably further down the spectrum than the D lines. I shou have described it as a muddy red.

Mr. Knobel. The Dun-Echt observations give that very da edge, which Mr. Maunder found at 5169, at 5162. On Dec. 18 it was 5156, and on Dec. 26th, 5162: and on a later occasion 5165. The mean therefore comes to 5162.

Mr. Lewis called attention to an occultation of Uranus as observ by him at Greenwich on Nov. 30th. Both at immersion and eme sion the interval between first and last contacts of the limbs Uranus with that of the Moon was about one second, whereas ought to have been some 7 seconds. The morning was very fin the Moon was in the last quarter, and the dark limb distinct visible.

The following papers were also announced:—

Major G. Strahan. "The Meteor-shower of 1885, Nov. 27th."

Major A. C. Bigg-Wither. "The Meteor-shower of 188 Nov. 27th."

Prof. C. V. Zenger. "On a new Spectroscopic Method fo Measuring close Double Stars."

G. L. Tupman. "Observations of Comet 1885 (Brooks) a Harrow, with the 18½-inch Equatoreal Reflector."

Communicated by *E. J. Stone.* "Observations of the Meteors o 1885, Nov. 27, made at the Radcliffe Observatory, Oxford."

R. A. Proctor. "Note on the Biela Meteors."

A. Marth. "Ephemeris of the Satellites of Mars, 1886."

B. J. Hopkins. "On the Variations in Colour of the Nov Andromeda, and on the Evidence it affords as to the Origin of th Nova."

Communicated by *E. J. Stone.* "Observations of the Moo made at the Radcliffe Observatory, Oxford, during the Year 1885 and a Comparison of the Results with the places computed from Hansen's Lunar Tables."

A. Marth. "Note on the Transit of the Planet Mars and its Satellites across the Sun's Disk, which will occur for the Planet Jupiter and its Satellites on April 13, 1886."

W. F. Denning. "Changes in the Red Spot on Jupiter."

Communicated by the *Astronomer Royal.* "Spectroscopic Results for the Motions of Stars in the Line of Sight obtained at the Royal Observatory, Greenwich, in the Year 1885.—No. IX."

Communicated by the *Astronomer Royal.* "Observations of Comets *d* 1885 (Fabry) and *ε* 1885 (Barnard) made at the Royal Observatory Greenwich."

Communicated by the *Astronomer Royal.* "Observations of Occultations of Stars and Uranus by the Moon, and of Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the Year 1885."

The following gentlemen were duly elected Fellows of the Society:—J. E. Evans, George Ford, B.A., Jacob Gerhard Lohse, William Irving Page, F.R.G.S., George Charles Parker, F.R.G.S., A.I.C.E., M.R.A.S., Julian Tripplin, and E. L. Trouvelot.

The Meeting adjourned at 10 P.M.

Liverpool Astronomical Society.

The Fourth Meeting of the Session was held on Tuesday, Jan. 12, 1886, in the Association Hall, Mount Pleasant. In the absence of the President, Mr. R. C. Johnson, F.R.A.S., presided (one of the Vice-Presidents). There was a good attendance of members and friends. Amongst those present were Messrs. W. H. Davies, F.R.A.S., H. Thomas, J. Gill, W. H. Sharp, J. Stead, W. H. Davies, jun., and J. W. Appleton, F.R.A.S., Honorary Secretary. Three gentlemen were elected members. A paper sent by Mr. R. Cross, of Oxford, on "The Andromeda Meteors," was read. He states that on Nov. 27, 1885, he and two others, about seven o'clock in the evening, counted as many as 500 in 15 minutes, that they fell from all points of the compass, so that it was impossible to count them, 8 or 10 falling at the same time. The radiant-point, as near as he could calculate, was γ Andromedæ. The Rev. S. J. Johnson, F.R.A.S., contributed a paper on "The Suspected New Star near χ Orionis." He says, "The appearance of Mr. Gore's star through a 3¼ in. as to colour, and very nearly as to magnitude, resembles the 'Nova' that lately shone out in the Andromeda Nebula, being just a trifle brighter than that one. But the point to which I would draw attention is that in Bode's maps (1782) I find a small star marked, which seems to occupy the position of this one. It is not in the larger or smaller maps of the S.D.U.K.

or in any other atlas I possess." Mr. J. E. Gore, F.R. M.R.I.A., contributed a paper, entitled, "Observations of Suspe Stars," giving a tabular statement, under the following heading "The following observations of some of the stars in my 'Catal of Suspected Variable Stars' were made by me during 1885. observations were made with a binocular field-glass, accura focussed on the star, and the estimated magnitudes are the res of careful comparisons with neighbouring stars." The table g the "No. in Catalogue; R. A. 1880, Declin. 1880; Date of ob vation; Estimated Magnitudes; and remarks upon the state of sky during the observations." This valuable paper will be publis in the Society's Journal. A paper by M. Armand Gunziger read, called "Table of Sun-spots visible to the naked eye f June 11 to December, 1885." All the observations were first m with the naked eye and then with a telescope. The Sun observed on 85 days, and on 34 spots were visible. The m remarkable were those of June 21, July 9, September 4 and these were large enough to be distinguished by the most in perienced observer. A paper was read, sent by Mr. Cattermole, c taining some useful hints on the construction of observatories,

Interesting observations followed each paper.

Large Telescopes v. Small.

I HAVE not intended any disrespect to the 'Observatory,' or Mr. Denning in postponing so long a response to certain rema and inquiries contained in his interesting paper which appea in your June number.

But I did not care to reply until I had been able to make so experiments bearing directly on the points in question, by observi the planets with our telescope capped down to various apertur and to do this it was necessary, of course, to wait for the planets come again into position.

During the past two months I have repeatedly observed Satu under very various atmospheric conditions, with powers rangi from 160 to nearly 1000, and with apertures varying from inches to 9. With only one exception the result has confirmed previous impression, that one can *always see with the larger apert every thing shown by the smaller, and see it more easily.* The sing exception was on one evening when the air was so extreme unsteady, that with a power of 300 the Cassinian division Saturn's ring could not be fairly made out with 23 inches; wi 9½ inches and the same eyepiece I *could* see it. I think, howeve that in this case a great part of the trouble was inside the telescop tube; the temperature had just fallen greatly and rapidly, so th the metal of the tube was much colder than the air within it, a the rays on the outside of the convergent cone were much mo disturbed than the central ones.

Whenever the seeing was "average," or above the average (*i. e.* above 5 on a scale of 10), the larger apertures had a decided advantage in every respect. I have not yet been able to try the experiment with Mars and Jupiter, but hope to before long.

In answer to Mr. Denning's inquiries, I may state that we have never been accustomed to use "stops" in observing—not even in observing *the Sun.* Under ordinary circumstances there is always an unquestionable loss of power over fine details by reduction of aperture.

It is true, of course, that the smaller beam of light incident on a smaller object-glass is less affected by atmospheric disturbance, and so, *quoad hoc*, with a given magnifying-power the image is better defined; but in an average state of the air *this* gain only just about offsets the loss due to the greater diffraction of the smaller lens. Moreover, there usually come, now and then, moments of exquisite seeing, even when the general seeing is poor, and during these critical instants of course all the advantage is with the larger lens.

So far as I can judge, the indistinctness of image due to atmospheric disturbance outside the telescope, instead of increasing with the square of the aperture, or its cube (?) as suggested by Dr. Robinson, is more nearly proportional to its square root, or perhaps to some logarithmic function. With our 23-inch and power of 300, the blurring and dancing of the image is certainly, under ordinary circumstances, not *twice* what it is in our 9½-inch with the same power.

A word also as regards diffraction: it does not follow that because the image of a line formed by a 9½-inch object-glass has a width of 0″·4, the instrument cannot therefore show as double a pair of lines that are only 0″·4 apart. The image of a line is not a stripe of uniform brightness from edge to edge, but a shaded streak intenser along the middle. A very faint star does not show a disk as large as a bright one, because we see only the central portion of its image. At the same time I ought, I suppose, to own honestly that I am rather sceptical as to some of the double-line markings reported upon Mars.

As to the magnifying-powers found most efficient on the 23-inch: on double stars we use 480 and 700 in *fair* seeing; 950 and 1200 on close objects in *fine* seeing. On Jupiter, Saturn, and Uranus, 300 or 480 usually, 700 often, 950 and 1200 exceptionally. The highest power named worked perfectly on Jupiter last spring (on two different evenings) in bringing out fine details relating to the great red spot, and showing the true form of certain white dots on the south-polar belt. Perhaps I ought to add that I prefer rather higher powers than many other observers would use under the same circumstances; probably because the defining power of my eye is less perfect. I think it likely that Mr. Denning, for instance, could have decided whether the "dots" spoken of were irregular in form or truly circular, just as well with a power of 600 as I could with [illegible]

As to atmospheric conditions, I have seen only four or five really first-class nights in three years (seeing, 9 or 10), and thirty or forty extremely good (seeing, 8). About one observing night in three the 23-inch is "*immensely* superior" to the 9½-inch.

Our meteorological conditions here are neither particularly good nor bad; nor, I suppose, compared with other Clark lenses, is the 23-inch object-glass remarkably superior; it is certainly excellent, but I think our 9½-inch is a little better, especially in the colour correction.

To sum up, I am quite sure that if Mr. Denning will come here and look for himself, he will after an evening or two agree with the rest of the large-telescope users. As to the detection of new features of planetary phenomena, that is largely a matter of eyesight and assiduity. It is very doubtful whether my eyes, even with our great telescope, could see everything that other "eagle-eyed" observers have made out with smaller instruments: and then, life is short, and there are other interesting telescopic objects besides planetary markings. C. A. YOUNG.

Princeton, N. J., 1886, Jan. 5.

Observations of Nova Andromedæ.

THE following observations were made with an equatoreally mounted achromatic of 6 inches aperture, with a power of 80, which is the power almost invariably used at this observatory in the determination of star-magnitudes:—

Date.	Observed Magnitude.	Remarks.
1885, Sept. 3	8·35	Colour orange. Nebula around Nova very ruddy.
5	8·35	Very light, but not bright orange. Nebula ruddy.
6	8·45	
7	8·5	Perhaps slightly more coloured.
8	8·65	Dull orange.
9	8·7	Dull yellow.
12	9·3	Colour unchanged.
13	9·25	Colour unchanged, but the nebula is not so ruddy as when Nova first appeared.
14	9·25	
18	9·8	
25	9·9	Very hazy sky and strong moonlight.
27	10·0	
Oct. 7	10·8	Well-defined; colour unchanged.
29	12·5	Estimated.
Nov. 8	. .	Not distinguishable.

The following observations were made by my son, Joseph Baxendell, Jun.:—

Date.	Observed Magnitude.	Remarks.
1885, Sept. 3	8·2	Light orange; the nebula has quite a fiery appearance.
5	8·3	
6	8·4	
7	8·4	Colour unchanged.
8	8·65	
9	8·65	
12	9·2	Colour still orange; nebula not now much coloured.
13	9·3	
14	9·3	Nebula not coloured.
18	9·3	Rather doubtful.
25	9·5	Hazy sky and strong moonlight.
27	9·5	Colour same as at first.
Oct. 29	12·2	Rather doubtful.

A projection of the observations shows that the gradual decrease of the star's brightness was interrupted between the 19th and 26th of September, during which time the change was extremely slight.

The Observatory, Birkdale, Southport, **Joseph Baxendell.**
1886, Jan. 18.

The Meteor-shower of Nov. 26–29, 1885.

Anticipating a possible return of the meteor-shower evidently connected with Biela's comet (and which furnished such a rich display on Nov. 27th, 1872), preparations had been made for observing meteors during the last week of November.

Cloudy weather and a severe storm prevailed on the 22nd, 23rd, 24th, and 25th, and partially cloudy weather on the 26th.

During a partially clear interval, however, on the 26th from 7^h to 8^h, a watch was maintained and the shower found to be in active operation. 42 meteors were recorded during the hour named, of which 37 were evidently conformable to the Biela radiant-point.

Owing to the hazy state of the sky only a few tracks were recorded accurately enough for deducing an approximate radiant-point, which appeared rather diffuse, but near χ Andromedæ.

The evening of the 27th was fortunately very clear and the shower was well observed.

The first meteor (a fine one > 1 mag.) was seen a few minutes after 5^h crossing Cygnus. The programme arranged was to occupy a portion of the time in registering such meteor-paths as were accurately observed for the purpose of determining the radiant-point, while the other portion of the time was to be spent in counting the number observed and noting their characteri features, such as magnitude, velocity, &c. Tracks were map from 5^{h} 30^{m} to 6^{h}, and from 7^{h} to 7^{h} 15^{m}, while the number s during each ¼ hour was recorded from 6^{h} to 7^{h}, and from 7^{h} : to 8^{h} 15^{m}. The meteors came in groups, a minute or more of elapsing without seeing one, and then 3 or 4 would be recorded in many seconds. The tracks of the meteors were generally short, w velocities from medium to slow, were accompanied by streaks, a were generally orange-coloured. A number of very fine ones w observed.

The following table exhibits the number registered each fift minutes :—

Duration of watch Nov. 27th, 1885.		Length of watch.	No. of Meteors seen.	Bielas.	Others.
From	to				
h m	h m	m			
6 00	6 15	15	39	38	1
6 15	6 30	15	44	41	3
6 30	6 45	15	39	37	2
6 45	7 00	15	38	36	2
7 15	7 30	15	28	28	0
7 30	7 45	15	28	26	2
7 45	8 00	15	23	23	0
8 00	8 15	15	22	21	1
6 00	8 15	2^{h}	261	250	11

The magnitudes of those recorded were as follows :—

	Mag. >1.	Mag. =1st.	Mag. =2nd.	Mag. =3rd.	Mag. =4th.	Mag. =5th and fainter.	Total.
Bielas ..	9	21	30	51	64	75	250
Others..	0	2	1	3	2	3	11
Total ..	9	23	31	54	66	78	261

The display was evidently on the decrease, as 160 meteors we recorded during the first hour, against only 101 during the la hour; 30 paths were quite accurately registered, including sever very short and nearly stationary ones near the centre of radiatio A careful reduction of these paths gives the radiant-point as R.A. 22⅓° +42½°, or between χ and υ Andromedæ. The eveni of the 28th was also clear, and a short watch was kept from 6^{h} 6^{h} 40^{m}, and three faint meteors were recorded, which evident belonged to the Bielas.

A short watch was also taken on the 29th from $5^h\ 45^m$, to $6^h\ 15^m$, and of three meteors observed two were conformable to the Biela radiant; so that the shower was certainly active from the 26th to the 29th. Centre of observation ν Andromedæ.

The intensity of the display as observed this year was nearly the same as the writer observed in 1872, when 131 meteors were recorded in 45^m, from $7^h\ 45^m$ to $8^h\ 30^m$, and 194 in 2 hours, from 9^h to 11^h on the 27th. The next return of the shower of any considerable magnitude will not probably occur until Nov. 1892.

Cambridgeport, Mass., U. S. A.
1885, Dec. 15.

EDWIN F. SAWYER.

The Chromosphere in 1885.

THE great diminution in spot-area on the solar surface, and the gradual disappearance of the bright faculæ, might lead to the supposition that the decrease of the chromosphere and of the prominences would be equally rapid. This, however, is scarcely borne out by the tabular results which form the principal part of this communication, although on certain days the prominences were found to be very few in number, and on January 23rd, with a bright sky, none at all could be detected. But if the eleven-year period is not showing itself at present in the prominences so well as in the spots, there has still been a variation common to both phenomena, the general increase from January to June, followed by the decrease from June to December, being quite as well marked in the extensions of the chromosphere as in the spot-area. The mean

Month.	No. of days of observation.	Mean height of chromosphere excluding prominences.	Mean height of prominences.	Mean extent of prominence arc.	Highest prominences.	No. of days on which C was displaced.
		″	″	° ′	′ ″	
anuary ..	5	7·35	21·11	9 48	1 13·47	0
ebruary ..	5	7 69	22·98	33 4	1 1·95	1
arch	10	8·07	30·80	23 21	1 51·50	3
pril	8	8·03	21·57	27 55	1 6·22	1
ay	3	7·82	29·48	34 37	1 3·23	2
ne	10	8·07	31·10	43 56	3 38·09	1
ly	13	7·99	28·75	33 34	1 34·37	7
gust	9	8·20	35·38	27 37	2 42·38	1
ptember ..	4	8·12	28·96	24 0	1 17·75	0
tober	3	8·24	34·18	28 10	1 29 71	2
vember ..	3	8·24	33·62	31 7	1 31·85	2
cember ..	6	8·20	27·13	23 47	1 4·93	0
ean 1885. .	6·6	8·00	28·67	28 25	1 37·95	1·7
„ 1884 ..	7·3	7·94	25·74	29 6	1 14·30	2·0
„ 1880-85.	5·9	8·07	25·71	32 45	1 20·19	—

height of the chromosphere remains, however, fairly constant, and the prominence arc is less in extent than in 1884, and much less than the mean of previous years; but, on the other hand, the mean of the highest monthly readings is the greatest on record, and the general height of the prominences is above the average. In July the displacements of the C lines were very numerous, but not many were noticed in the other months.

On July 21st a remarkable prominence was seen at 87° S. of E, and the following bright lines recorded:—W.L. 7055·20, 6677·6, C, D_1, D_2, D_3, a bright line about W.L. 5361·0 with no corresponding solar line, 1474 K, two bright lines near W. L. 5275·18 and 5233·72, W.L. 5210·6 with no corresponding solar line, b_1, b_2, b_3, W.L. 5017·76, 5015·4, 4933·55, 4923·20, 4921·44, and F.

Stonyhurst College Observatory. S. J. PERRY.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Proposed Maps for tracing Meteor-paths.

GENTLEMEN,—

I have long thought that the existing star-charts are inadequate for meteor observers.

The British Association maps prepared for them, though very useful, seem not sufficiently accurate for present requirements. Many observers make their own maps by inserting in skeleton charts, drawn on a preferred projection, just such stars as they need. This appears an unnecessary individual expenditure of labour, as if suitable maps were prepared they would do for all engaged in shooting-star investigations.

I therefore propose to get some printed, and shall be glad to receive suggestions from meteor observers who have any to make on the subject.

The following points sketch my present plan; about those to which ? is added I feel more doubtful than as to the others:—

There should be 14 maps, engraved with the utmost attainable accuracy, on the gnomonic projection, with centres at

R.A.	D.
0°	±90°
45 135 225 315	±45
0° 90 180 270	0°

Diameter 140°. Square; length of edge 24? inches. The maps will thus overlap each other a great deal, one advantage of which would be the facility of transference of a meteor-path from one map to another.

R.A. and D. circles to be finely drawn (in same coloured ink, and at same printing as the stars) for every degree of D., and for every degree of R.A. except near the poles. The R.A. and D. to be given in degrees marked at each interval of five; and the hours of R.A. to be marked also?

The sky to be represented as seen with the naked eye, but without the Milky Way. Stars and cumuli to be inserted to 6·5? magnitude; and fainter stars also, separately, when they are cumulatively as bright, like as in the 'Uranometria Argentina' maps. To attempt completeness in this respect, all the stars to the adopted limit of magnitude in the catalogues of the 'Uranometria Argentina,' of the 'Harvard Photometry,' and of Heis will be taken; and other catalogues consulted for supplying omissions, with the chief object of ascertaining the individual stars of which the double and multiple stars in Heis are composed, as he does not give them: about such catalogues information would be very useful and is solicited.

The positions of the stars to be taken from the various Greenwich (especially the Nine-Year for 1872), Radcliffe, and Cape Catalogues; for the epoch 1900? An accompanying catalogue of the stars mapped to be printed, like those of Argelander and of Heis?

The name to appear in each constellation, and be frequently repeated—abbreviated (or by symbol for the zodiacal constellations?)—near its borders, to facilitate recognition of outlying stars. The usual constellations to be adopted: not Bode's.

Every star to have a designation, and one only: to be taken in order, thus:—1. Greek letters; 2. In some cases, Roman capital letters, as in Camelopardus and for variable stars; 3. Flamsteed's Nos.; 4. Roman small letters; 5. B. A. C. Nos.?; 6. Nos. from the 'Uranometria Argentina,' to be distinguished by G (for Gould)?; 7. Nos. from 'Harvard Photometry' (H. P.)?; 8. Lalande's (Ll.) Nos.?; 9,....?

Many observers give the position or direction of meteors observed in degrees of R.A. and D.; while others make reference to stars. The latter method seems to be simpler and more exact; but it is unsatisfactory on turning to a map to find that stars conspicuous in the heavens are wholly omitted, or marked in without a name of any kind. The above suggestions are made with a view to supply such deficiencies.

Magnitudes to be represented by black circles of various sizes: perhaps with a white centre to the brighter stars?, shaped differently, as in Proctor's 'New Star Atlas;' care being taken that the white and black have one centre. Stars that vary considerably to be depicted of the minimum magnitude, with surrounding circle of maximum.

All designations of stars to be in ink of some other colour than that for the stars themselves—say blue?

Precession to be shown in various parts of the maps, in some such way as in Proctor; exhibiting apparent motion of stars in 100 years relatively to lines of R.A. and D. Perhaps this would involve giving lines of latitude and longitude also.

The position of the horizon, say of Greenwich, at midnight, fo fortnightly intervals, to be shown by a line on both edges of eac northern and equatoreal map; with an accompanying list of hour at which the horizon has the same position on other dates.

A copy of each of the three patterns of lines of R.A. and D used in the fourteen maps to be printed on tracing-paper, and supplied with each set of maps. Means should be afforded of measuring 1° in every direction at any part of a map.

The sets of maps not to be bound, but each map be separatel removable from a cover.

Sunderland, 1886, Jan. 19. T. W. Backhouse.

Proposed Change in the Astronomical Day.

Gentlemen,—

I have read M. Gautier's paper in your December issue and I venture to ask you to allow me to express my opinion on the question of the proposed change in the astronomical day.

The inconvenience arising from a rupture in the continuity of our Ephemerides of all kinds appears to me to be so very serious that on this ground alone I should prefer to see the present system continued.

Every astronomer must occasionally feel some embarrassment in his calculations where questions of old style and new style arise. If we are now to have yet another style superadded it will, I think, largely increase the trouble attending accurate computation.

The advantages claimed for the change appear to me quite insufficient to compensate the grave inconvenience of alteration.

Observatory, Co. Dublin,
1885, Dec. 24.

Yours truly,
Robert S. Ball.

The Meteoric Shower of Nov. 27.

Gentlemen,—

The following account of the above shower, as seen by various observers at Mauritius, may perhaps be of interest.

Meteors were first noticed about 7 P.M. and were seen from that hour up to 11 P.M. As far as could be judged, they were most numerous between 9 and 10. Unfortunately at the Observatory the sky became overcast soon after 9 and remained more or less so till 11 P.M. In other parts of the island the sky was clear. In 15 minutes, at about 9 P.M., 396 meteors were counted. The display from 8.30 to 9.20 was very fine, meteors being visible in every part of the heavens, and sometimes as many as four or five seemed to start from the same point, one after the other, and passing overhead, disappeared near the southern horizon. At 9, the radiant-point, which seemed to be not far from γ Andromedæ, was nearly on the meridian, with an altitude of only 28°, so that few meteors were noticed to the north of it.

At times the number of meteors visible would suddenly increase for about 4 or 5 minutes and this was followed by a lull. Most were of the second magnitude, some as bright as Sirius, but none so bright as Venus, at the time visible at W.S.W. The normal colour was white. Few of the meteors lasted more than 2 or 3 seconds and the trains extended sometimes to 30 degrees. Some meteors were traced from near the radiant-point overhead and almost down to the horizon, which would give a maximum length of path of nearly 100°. Even a cursory inspection showed that all the meteors radiated from some point in Andromeda, and by careful watching it was found that most of the paths intersected a few degrees N. of γ in that constellation; and this observation was confirmed by the fact that between $9^h\ 40^m$ and 10^h P.M., through breaks in the clouds, 4 stationary meteors were observed a few degrees to the north of the same star.

This shower was well seen at sea on board the Currie steamer 'Duart Castle,' when off Cape St. Mary south of Madagascar, and lasted from sunset to midnight.

Yours truly,
H. J. Bell.

The Variable Star η Argûs.

Gentlemen,—

In Miss A. M. Clerke's excellent 'Popular History of Astronomy during the Nineteenth Century,' she says, speaking of η Argûs (p. 63), "it has now regained so much of its light as to shine with nearly the same lustre as when Halley observed it two centuries ago." This, of course, would be the fourth magnitude, which Halley found η Argûs to be when he observed it at St. Helena in 1677. Now I do not think there are any *published* observations of this star later than those of Mr. Tebbutt in the 'Monthly Notices' for March 1877 (vol. xxxvii. p. 280*), according to which the magnitude still remained a little above the seventh at the end of December 1876. It had then only diminished by about half a magnitude since 1870. As Miss Clerke may have derived the above statement from private information, I should be glad to know from some of your southern correspondents whether the star really has increased in brightness since 1876. If we assume with Loomis that the principal period is about seventy years, and take 1843 as the last epoch of maximum brightness, the last minimum would be at about the time of the latest published observation of Mr. Tebbutt. Or, if we consider the outburst in 1843 to have been due to some special cause, and that the last regular (so to speak) maximum was in 1838, we may still more expect an augmentation to have taken place by this time.

Yours faithfully,
W. T. Lynn.

Blackheath, 1886, Jan. 15.

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* In the Index to the volume, p. 477, there is an erratum at the reference to this star, which is called γ instead of η Argûs.

Occultation-Cycle.

GENTLEMEN,—

The occultation of Aldebaran on the 16th was hidden from view here by clouds, as also were those last year; but the singular closeness of the 19-year return of this occultation is curious—

1886, January 16: Im. $7^h\ 48^m$, Em. $8^h\ 49^m$.
1867, January 16: Im. 7 26 , Em. 8 37 .

At the previous period the occultation happened a little earlier in the day—

1848, January 16: Im. $3^h\ 44^m$, Em. $4^h\ 29^m$.

Still closer returns sometimes come round; for instance:—

1849, November 30: Im. $3^h\ 43^m$, Em. $4^h\ 42^m$.
1830, November 30: Im. 3 39 , Em. 4 37 .

Melplash Vicarage, Dorset,
Jan. 18, 1886.

Faithfully yours,
S. J. JOHNSON.

Satellites of Jupiter.

GENTLEMEN,—

I should be greatly obliged if you would permit me to ask your readers who may observe, in the coming season, any abnormal appearance of the satellites of Jupiter, whether during transit or at any other position of their orbit, to forward an account of such to me at the address given below.

I may be permitted to say, from the study of a very extensive correspondence, that not only is the literature of the subject in a very unsatisfactory condition, but that essential facts in immediate connection with the phenomena are often obscure and even disputed. I invite the co-operation of your amateur readers, with a view to systematize and discuss their observations, to separate the objective and physical phenomena from the subjective or possibly instrumental appearances, in order to submit some working hypothesis which may explain the more prominent phenomena.

The ephemerides published from time to time by Mr. Marth for the study of the physical appearance of Jupiter must induce a great number of observers to give very considerable attention to the planet's disk; and it is felt that with a very little more trouble these same observers might do a great deal to elucidate much that is at present perplexing in the behaviour and appearance of the satellites.

I should be equally gratified to any who would undertake the systematic examination of the satellites, whether photometrically or otherwise, with a view of ascertaining if their light-reflective ability is constant in all parts of their orbit, due allowance being made for the disturbing influence of a neighbouring satellite, by the effect of the superior light of Jupiter being immediately at hand, or, lastly, by the possible change in the amount of reflected light due to a particular position of the satellite in its orbit.

I would further call attention to careful observation of the transit of the shadows of the satellites as likely to possibly throw some light on the vexed question of contrast, more especially as they may be seen on differently coloured or illuminated portions of the disk. Careful examinations of such appearances might lead one to be able to say what amount of effect can be produced by variously coloured and illuminated backgrounds.

In all cases I should be obliged by replies being arranged according to the following plan, which will enable me to compare the observations of different observers :—

Date. G.M.T.	Reflector or Refractor.	Power or Powers.	No. of Satellite.	Position-angle of Satellite.	Peculiarity observed.	Position-angle of other Satellites at time of observation.

To which may be added :—

1. The temperature of the wet- and dry-bulb thermometer.
2. The reading of the barometer.

In order to insure the identification of the satellite and the removal of any possible error, it would be desirable to give not only the position-angle of the satellite reckoned in the conventional manner of double-star measurements, but the distance given with some degree of approximation.

Truly yours,
Edmund J. Spitta.

Ivy House,
Clapham Common, London, S.W.,
Dec. 23, 1885.

Meteors with Shifting Radiants.

Gentlemen,—

The observations of Denza and Schiaparelli on the shifting of the radiant-point during the late shower of Andromedes are of a very striking character and I believe a less marked shifting was also noticed by Mr. Denning. The latter observer has already ascertained a very decided shifting in the case of the Perseids. The duration of this shower according to Mr. Denning is 26 days, from July [illegible] to August 21st, during which period the radiant-point continuously changes from night to night, the total change in R.A. amounting to 41°. The change in declination is comparatively small, as would also appear to be the case with the Andromedes.

Of the four meteor-showers which have been connected with comets it would thus appear that two possess shifting radiant-points, and I believe there is nothing to negative this conclusion as regards the other two. This shifting may prove to be a peculiarity of cometary showers; or, on the other hand, we may have failed to connect some meteor-showers with the corresponding comets by starting with an assumption which is only true of showers with shifting radiants.

Possibly the true state of the case is as follows. Let a meteor-stream approach the Earth in such a direction that if the meteors were wholly unaffected by the motion of the atmosphere the radiant-point would be at A, while if they fully participated in the motion of the atmosphere the radiant-point would be at B. Th the observed radiant-point will be somewhere in the arc AB ar probably not quite at the same point for all the meteors in tl shower. If the shower lasts for some time the radiant-point w shift with the motion of the Earth when it is situated near A, b will remain almost stationary when it is situated near B. Anoth kind of shifting, however, may take place which alone would expla the observations of Denza and Schiaparelli. A change might tal place in the character of the meteors arriving from this directio which would render them more or less susceptible to the influen of the atmospheric motion, and the radiant-point would according shift from A towards B or from B towards A. If, for example, tl average size of the meteors increased or diminished as the show progressed, we might expect some such result. The small meteors would be more completely carried away by the atmospher current when they entered it.

That there are stationary radiants and shifting radiants seem to be clearly established, and observation seems to show that th difference is not to be explained by a great difference in the initi velocities of the meteors. I have therefore ventured to propose different explanation.

Truly yours,
W. H. S. Monck.

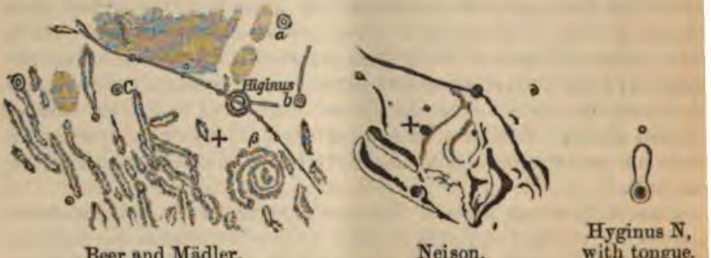
Dublin, 1886, Jan. 4.

P.S.—I may observe that a change in the average size of th meteors might, under certain circumstances, have the reverse effec to that which I have above ascribed to it. The smaller meteors migh be vaporized before the full motion of the air was impressed o them, while the larger ones survived long enough for that purpose

Hyginus N.

Gentlemen,—

Mr. Neison's letter in the 'Observatory' for December ha led me to examine again the marking in Beer and Mädler's map, t which Mr. Rand Capron had drawn attention. I find that th marking is quite plain in the later editions of the map, and ha evidently not been altered since the first edition, so that I do no think any light would be thrown on the subject by comparison wit a better preserved copy of the latter, as Mr. Neison suggests.



Beer and Mädler. Neison. Hyginus N, with tongue.

The Region about Hyginus N.

It does not seem to me, however, that the marking in question is so far from the position of Hyginus N as Mr. Neison thinks. I subjoin an outline copy of Mr. Neison's drawing of the region, from Klein's 'Anleitung,' reduced as nearly as possible to Mädler's scale. I have indicated by a cross Hyginus N as drawn by Mr. Neison, and the marking on the tracing from Mädler's map, which is also reproduced. The similarity in the positions of the two markings is, I think, pretty evident.

Mr. Neison also says that the Mädler marking does not resemble Hyginus N in "form, size, or nature." With regard to this statement, Mr. Rand Capron has drawn my attention to the fact that there is a small *tongue* or valley[*], which runs from Hyginus N nearly as far as the small crater to the south of it. Under certain circumstances of illumination, this converts the whole object into a somewhat oval or oblong figure. This *tongue* is omitted by Mr. Neison; but had it been inserted, the resemblance of his drawing to that of Mädler would have been much more evident. Indeed I think there are, in many good lunar maps, quite as considerable discrepancies in the delineation of formations with regard to which no suspicion of change has ever arisen.

Mr. Neison also refers to Mädler's large scale map of the region. I think, however, that too much has been made of the evidence of this special map, on account of the proximity of the part in question to the edge of the drawing. I find, in fact, that both Klein and Neison place Hyginus N at nearly the same distance N.W. of Hyginus as Triesnecker *a* is to the S.E. of it. If this be the true position of Hyginus N, it would be outside the limits of Mädler's special map altogether.

Yours truly,

W. H. WESLEY.

NOTES.

A NEW METHOD OF DETERMINING THE AMOUNT OF ASTRONOMICAL REFRACTION[†].—M. Loewy has recently communicated to the Académie des Sciences an account of a method which he considers to be specially adapted for determining the constant and other elements of refraction. The principle of the method is this: a glass prism with silvered faces, forming a double mirror, is placed in front of the object-glass of an equatoreal. By means of this arrangement the images of two stars which are widely separated in the sky can be brought close together in the focal plane of the telescope; thus one star may be at the zenith and the other on the horizon, in which case the measured distance between the images will be largely affected by refraction. After an interval of three or four hours, when the stars are at an equal height above the horizon, and when, therefore, the effect of refraction is a minimum, the distance between the images is again measured. The comparison of these two observations gives the means of determining the amount of the refr tion with great accuracy. It is of course necessary for the succ of the method that the measures should be absolutely independ of every possible displacement of the apparatus in the inter between the observations. This result is attained by placing t double mirror in such a position that the planes of reflection the two stars coincide; as M. Loewy finds that under these c cumstances, whatever small displacements the prism may underg the distance between the images in the field of the telesco measured in the plane of reflection, or the projection of this distan on the trace of the plane of reflection in the field, remains invariab M. Loewy claims for his method that, on account of its simplici and the ease with which it can be put in practice, it completely solv the problem to which he applies it. A few experiments ought show whether it is capable of affording results sufficiently accura to make the method of practical value.

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[*] Shown in Mr. Rand Capron's drawing in the 'Observatory,' vol. v. pl. ii.

[†] 'Comptes Rendus,' Tome cii. No. 2.

The Pulkowa Observatory.—We have received M. Struve Annual Report, presented May 25, 1885, on the work of the obse vatory during the year. The great 30-inch refractor had not y been brought regularly into use; but at the time of writing th report observations with it were to be commenced immediatel The observations with the 15-inch equatoreal, which for the la 45 years have been M. O. Struve's own special work, are no undertaken by his son Hermann Struve, as he himself has been to much occupied with other work, as well as having been incapacitate by a long illness. Micrometrical measures (98 in all) of th relative positions of Iapetus and Titan, Titan and Rhea, and Rhe and Dione have been made during the year. It is hoped that thes measures, in combination with those made in former years, wil furnish very accurate elements of the orbits of these satellites H. Struve has also made observations for determination of th parallaxes of 10 stars, as well as determinations of the positions o Encke's and Wolf's comets. The relative positions of 116 fain stars, which were occulted by the Moon during the total eclipse o Oct. 4, 1884, have also been determined with this instrument Observations with the great transit instrument have been continued by Wagner, with Wittram as his assistant. The observations (2348 in number) have chiefly been of the Pulkowa Hauptsterne. With the vertical circle Nyrén has zealously pursued his work of determining the declinations of the Hauptsterne. Of the 895 observations made during the year, no fewer than 832 were made in both positions of the instrument. In addition to these, 103 observations of the Sun were obtained. Romberg, observing with the meridian circle, has obtained 1236 observations in both elements of different stars taken from 1. The Abo Catalogue; 2. The Pulkowa Catalogue of Double Stars; 3. Stars used for Comet observations; 4. Stars used for determining the scale of the heliometer. With the 4-inch Repsold heliometer, Backlund has obtained 32 measures of distances and 30 measures of position-angles of Jupiter's satellites. Lindemann has investigated the variation of light of V Cygni with the Zöllner photometer ('Observatory,' No. 104, p. 435), and also has observed some other stars, the variability of which has been suspected. Hasselberg's spectroscopic researches have been limited to the chemical elements, nitrogen and hydrogen, which, however, are not yet finished. Photographs of the Sun have been regularly taken throughout the year, for which work gelatine plates have been found specially convenient. During the year 220 photographs have been obtained on 173 days. Referring to the work carried on at the Marine observatory at Nicolajew, M. Struve remarks that the director has found at Batum an extraordinary deviation of the plumb-line amounting to $49''\cdot6$ in longitude, $=37''\cdot1$ of a great circle in the direction of the prime vertical. In latitude the deviation is $16''$. That no volume of Pulkowa observations has been published during the year is owing chiefly to the long illness and multitudinous occupations of the director. The following volumes, however, are in active preparation:—Volume VIII., which contains the Star Catalogue compiled from the meridian observations 1839 to 1869; Volume X. containing the continuation of O. Struve's measures of double stars; Volume XII., containing the fundamental determinations of R.A. for 1865·0; and Volumes XIII. and XIV., containing the fundamental determinations of declination for the same epoch. The work of the Geographical and Geodetical Bureau under Döllen's superintendence has also been carried on as usual during the year.

THE GREAT PULKOWA REFRACTOR.—From M. Struve's Report we learn that he was chiefly occupied during the year with work incidental to the installation of the great 30-inch refractor. It was anticipated that by September 1884 things would be in such a state that it would be possible to begin to observe with this gigantic instrument; but owing to various delays, chiefly connected with the construction of the dome, it was not until the end of September that the Repsolds could be invited to come to Pulkowa to superintend the work of erecting the telescope; this was accomplished very successfully by them in about three weeks. And M. Struve expresses himself as greatly pleased with the ease with which the telescope can be set, with the equality of the illumination on all its parts from a single lamp, with the accuracy with which the driving clock performs, and with the facilities for altering the telescope into a powerful spectroscope; so that this great instrument may be regarded as the successful outcome of the highest skill of modern art in this department. Further work on the dome was interrupted by the approach of winter; but at the time of writing his report, M. Struve states that regular observations could be commenced immediately. At present the dome is moved by hand; it is hoped, however, that this may eventually be done by electricity, and that a motive power will thus be obtained sufficient to overcome the hindrances to the rotation of the dome arising from snow and frost. From investigations made by H. Struve it appears that the position of the polar axis is correct to a fraction of a minute, the change in focal length of the instrument during the winte but trifling, and that, notwithstanding the great weight of object-glass and of the eye-end, the flexure of the telescope i small as to be practically insensible. M. Struve proposes to the great refractor for observing such double stars as are bey the reach of the 15-inch equatoreal, and to undertake observati of certain interesting nebulæ, as well as spectroscopic researche stars in cases where the great optical power of the instrument make the observations of special value.

NEWTON AND HIS NIECE *.—This posthumous work of Prof. Morgan has been edited by his wife and by his pupil Mr. A. Ranyard. It has been enlarged from the size of an article writt in 1858, for (but not published in) 'The Companion to Almanac.' It was revised and received some additions in the ye 1864–6, and later still was enlarged to the form in which it n appears. The book contains an elaborate discussion of the evide bearing on the relations existing between Newton's niece, Cather Barton, and Lord Halifax his patron. Voltaire, in 1765, in 'Lettres Philosophiques,' says "I thought in my youth that Newt made his fortune by his merits. No such thing. Isaac Newton ha very charming niece, Madame Conduit, who made a conquest the minister Halifax. Fluxions and gravitation would have be of no use without a pretty niece." In opposition to this view the matter, De Morgan holds that Halifax and Miss Barton we privately married, and brings forward a vast number of more less cogent arguments in support of this method of upsetting t theory that Newton connived at, and owed his appointment at t Mint to, the dishonour of his relative. The strongest piece evidence produced by the author, and which, taken in conjuncti with other matters, he considers to be a "proof" of the marriage, is letter of Newton's written just after the death of Halifax in 171 in which the following passage occurs:—"The concern I am in f the loss of my Lord Halifax, and *the circumstances in which I sta related to his family*, will not suffer me to go abroad till his funer is over." Of course everything which concerns the private life a character of the great philosopher must be of interest to astr nomers, and we are therefore under an obligation to the Editors this little volume for having published these details, the more so they were collected by such an enthusiastic "Newtonian" as wa Prof. De Morgan.

ASTRONOMICAL PRIZES OF THE ACADÉMIE DES SCIENCES.—Th Lalande Prize has been awarded to M. Thollon for his map of th Solar Spectrum, and the Valz Prize to Herr Spoerer for his thirt years' work on the physical constitution of the Sun.

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* Newton: his Friend: and his Niece. By the late Augustus De Morgan Elliot Stock: London, 1885.

THE DOUBLE STAR *p* ERIDANI.—Mr. Tebbutt, of Windsor, N.S.W., has recently published ('Monthly Notices,' Vol. xlvi. No. 2) some measures of this interesting double star. The following are his results, together with the errors of the places computed from Downing's orbit ('Monthly Notices,' Vol. xliii. No. 5):—

Epoch.	Angle.	Error.	Distance.	Error.
	°	°	″	″
1880·58	233·6	+0·5	6·42	−0·54
1882·18	233·0	−0·2	7·01	−1·10
1885·19	230·5	+0·2	7·10	−1·07

It would appear that the semi-axis major adopted in the above orbit requires modification. Mr. Tebbutt's measures were made with a 4½-inch equatoreal not driven by clockwork—a striking instance of excellent work done with small instrumental means.

NEW OBSERVATORY IN INDIANA.—The De Pauw University, Indiana, has been enriched by the present of an Observatory, a gift of Mr. R. M'Kim, of Madison. The equatoreal has a clear aperture of 9·53 inches. For clock errors an Almucantar is to be used. The dome for the equatoreal is seventeen feet in diameter and has been made by Messrs. Warner and Swasey, of Cleveland, and is fitted with their peculiar system of friction rollers.

The following extract from the 'Sidereal Messenger' describes the results obtained by their means:—"The dome is to the observer a continual source of satisfaction and comfort. There is no gear-wheel, no crank, no windlass, no grinding at the dome or shutter, until the muscular exertion has unfitted one for accurate work. A simple straight arm comes down along the wall, and a pull which would register twelve pounds on a spring balance will move the dome readily. The shutter, although made in one piece, moves with a pull of only eight pounds, and when open, the impact of the wind against the shutter can revolve the dome." Dr. T. P. John is the Director.

EFFECT ON THE EARTH'S MOTION PRODUCED BY SMALL BODIES PASSING NEAR IT [*].—In this paper Prof. H. A. Newton points out that the space through which the Earth travels is traversed also by small bodies, or meteoroids. The impact of these bodies upon the Earth, and the consequent increase of the Earth's mass, have their effect upon the Earth's motions both of rotation and revolution, and hence upon the lengths of the day and year. Prof. Oppolzer (Astron. Nachrichten, No. 2573) has discussed the amount of these actions, and has computed the density which the meteoroid matter must have in order to produce the observed and unexplained acceleration of the Moon's mean motion. But a body that passes near to the Earth has also an action of like character due to the attraction of gravitation alone, and Prof. Newton proceeds to calculate its amount. The conclusion at which he arrives is that the effect upon the Earth's motion of the meteors that come into the Earth's atmosphere exceeds at least one hundredfold that of the meteors that pass by without impact.

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[*] 'American Journal of Science,' December 1885, pp. 410–417.

METHOD OF SUPPORTING A MERCURY-TROUGH FOR REFLECTION-OBSERVATIONS *.—The observation of the Nadir has hitherto been almost impossible at the Paris Observatory, owing to the disturbance of the mercury caused by the traffic in the neighbouring streets. Lately, however, M. Gautier has devised a very simple arrangement by which this inconvenience is obviated. The new apparatus consists of two cylindrical basins placed one above the other, the lower one, which contains the supply of mercury, having a slightly larger diameter than the upper. The bottom of the lower basin is pierced at its centre, to admit a screw which projects in a vertical direction into the inside, and is fixed in that position. A cylinder, fixed as an axis to the bottom of the smaller basin, is tapped to fit the projecting screw; and thus by turning this basin round its axis, it can be raised or lowered in the larger vessel so as to obtain a supply of mercury in it (by means of an opening provided for the purpose) sufficient for observation, whilst the oscillations of the ground, Admiral Mouchez states in the paper before us, are completely counteracted by the "demiflottage" of the second basin.

THE LATE DR. J. C. DRAPER.—We regret to have to record the death of Dr. J. C. Draper on Sunday, Dec. 22, in the 51st year of his age. He was the eldest son of the late Prof. John W. Draper. The departments of science to which he chiefly devoted himself were medicine, chemistry, and natural history, graduating as M.D. in the University of the City of New York in 1857, where he held the chair of natural history from 1863 and of chemistry in the medical department of the college from 1866. He took a great interest besides in spectroscopy; and about the time that his brother (Dr. Henry Draper) believed he had obtained evidence of the existence in the solar spectrum of *bright* lines due to oxygen he published a series of measures of solar *dark* lines, which he considered corresponded to the spectrum of that gas. His death will be felt as a severe loss to American science.

THE R.A.S. COUNCIL.—Mr. Downing wishes to point out that his name was omitted from the Balloting List for Officers and Council of the Royal Astronomical Society for the ensuing year proposed by the Council, at his own request, on the grounds that he has now been on the Council for four years consecutively, and that, in his opinion, is sufficiently long for him to have been on at one time. He therefore ventures to ask those Fellows who make use of the "Opposition" list to insert a fresh name in place of his.

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* 'Bulletin Astronomique,' Tome ii. p. 549.

The Council of the Royal Astronomical Society have awarded the Society's Gold Medal to Professors Pritchard and Pickering for their photometric researches.

We would draw our readers' attention to Mr. Spitta's letter on the Satellites of Jupiter, and trust that many will be able to give him the assistance he seeks.

Minor Planet No. 251 has been named Sophia by Dr. J. Palisa, of Vienna.

We note with much pleasure that Dr. R. S. Ball, Royal Astronomer for Ireland, received the honour of knighthood on Jan. 25.

Elements and Ephemeris for Comet Brooks 2[*].

By Dr. H. Oppenheim.

A comet was discovered by Mr. W. R. Brooks, Red House Observatory, Phelps, New York, on Dec. 26. It was also independently discovered by Mr. E. E. Barnard, Vanderbilt University, Nashville, Tennessee, on the following night. The latter describes it as "of the average size and brightness of telescopic comets, with a slight central condensation, but no nucleus or tail." It is the sixth comet of 1885 in order of date of first observation, but the fourth as regards perihelion passage, Fabry's and Barnard's comets not coming to perihelion until the present year is far advanced.

The following elements were computed from observations made at Harvard College on Dec. 28, at Vienna, Jan. 1, and Berlin, Jan. 7.

$$T = 1885 \text{ Nov. } 24{\cdot}7806 \text{ Berlin M.T.}$$

$$\left.\begin{array}{lrrr} \pi \ldots\ldots\ldots\ldots & 296^\circ & 38' & 45'' \\ ☊ \ldots\ldots\ldots\ldots & 262 & 1 & 48 \\ i \ldots\ldots\ldots\ldots & 42 & 25 & 11 \end{array}\right\} \text{Mean Eq. } 1885{\cdot}0.$$

$$\text{Log } q = 0{\cdot}03012.$$

Error of the middle place (O – C).

$$d\lambda = -4'' \qquad d\beta = -2''$$

Ephemeris for Berlin Midnight.

	App. R.A.			App. Dec.				Bright- ness.
1886.	h	m	s	°	′	Log r.	Log Δ.	
Jan. 30..	22	4	14	+18	18·5	0·1802	0·3295	0·5
Feb. 3..	22	18	21	19	40·7	0·1925	0·3392	0·4
7..	22	32	11	20	58·6	0·2046	0·3493	0·4
11..	22	45	43	22	12·0	0·2165	0·3595	0·4
15..	22	58	57	23	21·2	0·2282	0·3700	0·3
19..	23	11	52	24	26·4	0·2398	0·3806	0·3
23..	23	24	27	25	27·6	0·2511	0·3912	0·3
27..	23	36	46	26	25·1	0·2622	0·4019	0·2
Mar. 3..	23	48	46	+27	19·1	0·2731	0·4125	0·2

The brightness on Dec. 28 is taken as unity.

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[*] Astron. Nachr. No. 2706.

Ephemeris for Comet Fabry.* By Dr. H. Oppenheim.

For Berlin Midnight.

	R.A.			Dec.				Brigh
1886.	h	m	s	°	′	Log *r*.	Log Δ.	ness
Feb. 3..	23	24	22	+24	5·2	0·1255	0·2287	2·4
7..	23	23	28	24	46·4	0·1050	0·2252	2·7
11..	23	22	43	25	31·6	0·0834	0·2204	3·0
15..	23	22	6	26	20·7	0·0607	0.2140	3·5
19..	23	21	32	27	13·7	0·0370	0·2058	4·1
23..	23	21	0	28	10·6	0·0121	0·1958	4·8
27..	23	20	27	29	11·0	9·9860	0·1836	5·7
Mar. 3..	23	19	49	+30	14·8	9·9591	0·1689	6·9

The brightness on 1885 Dec. 1 is taken as unity.

Elements and Ephemeris for Comet Barnard.*

By Dr. A. Krueger.

The following elements and ephemeris have been computed fro observations made at Dresden, Dec. 5, Berlin and Hambur Dec. 26, and Hamburg, Jan. 11.

$$T = 1886 \text{ May } 3{\cdot}14855 \text{ Berlin M.T.}$$

$$\left.\begin{array}{l} \omega \;\ldots\ldots\ldots\; 119^\circ\ 40'\ 50''{\cdot}7 \\ \Omega \;\ldots\ldots\ldots\; 68\ \ 21\ \ 43\ {\cdot}9 \\ i \;\ldots\ldots\ldots\; 84\ \ 14\ \ 21\ {\cdot}9 \end{array}\right\}\ \text{Mean Eq. } 1886{\cdot}0.$$

$$\text{Log } q = 9{\cdot}679322.$$

Error of middle place (C−O).

$$d\lambda = +4''{\cdot}2 \qquad d\beta = +1''{\cdot}9$$

The heliocentric coordinates from the foregoing elements are :-

$$x = r\,[9{\cdot}580193]\sin(223^\circ\ 52'\ 47''{\cdot}4 + v)$$
$$y = r\,[9{\cdot}966804]\sin(232\ \ 41\ \ \ 8\ {\cdot}3 + v)$$
$$z = r\,[9{\cdot}999367]\sin(141\ \ 25\ \ 39\ {\cdot}6 + v)$$

Ephemeris for Berlin Midnight.

	R.A.			Dec.				Bright
1886.	h	m	s	°	′	Log *r*.	Log Δ.	ness.
Jan. 29..	2	19	50	+13	43·2	0·2799	0·2251	2·2
Feb. 2..	2	15	9	14	35·4	0·2657	0·2290	2·3
6..	2	11	1	15	29·0	0·2508	0·2328	2·4
10..	2	7	24	16	24·3	0·2352	0·2362	2·5
14..	2	4	20	17	21·3	0·2189	0·2390	2·7
18..	2	1	42	18	20·1	0·2017	0·2412	2·9
22..	1	59	29	19	20·7	0·1836	0·2426	3·1
26..	1	57	39	20	23·4	0·1646	0·2432	3·4
Mar. 2..	1	56	8	+21	28·4	0·1443	0·2429	3·7

The brightness on 1885 Dec. 5 is taken as unity.

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* Astron. Nachr. No. 2706.

ERRATUM IN No. 106.

Page 80, line 25, *for* 1885 *read* 1886.

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HE OBSERVATORY,

MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
eeting of the Royal Astronomical Society on February 12......... 113
e Liverpool Astronomical Society 116

Lunar Inequalities due to the Ellipticity of the Earth. By Prof.
ams, M.A., F.R.S. 118
Minima of Variable Stars. By George Knott, F.R.A.S. 120
ble Star T Aquilæ. By Joseph Baxendell, F.R.S., F.R.A.S.... 122
Star S Vulpeculæ. By Joseph Baxendell, Jun. 124
tronomy in the Nineteenth Century. By E. W. Maunder, F.R.A.S. 126
ence:—
Ancient View of the Solar Corona without an Eclipse. By W.
, B.A., F.R.A.S. 128
ange in the Astronomical Day. By J. L. E. Dreyer, F.R.A.S. 130
ors. By W. H. S. Monck, M.A. 131
Photometer. By Henry Parkhurst.. 132
f 1812 (Pons-Brooks) in 1884. By T. W. Backhouse, F.R.A.S. 133
of the Royal Astronomical Society. By the Rev. Prof. C. Prit-
F.R.S. 133

bservatories.—A New Observatory in Hungary.—Stability of
's Rings.—Halley's Southern Catalogue.—The Washington Ob-
ory.—The Leiden Observatory.—The Double Star 61 Cygni.—
ity of Iapetus.—The Temperature of the Surface of the Moon.—
es in the Radiation of Heat from the Moon during a Lunar
e.—Minor Planet No. 250 134–142
d Ephemeris for Comet Brooks 2. By Drs. H. Oppenheim and
.... 143
d Ephemeris for Comet Fabry. By Dr. H. Oppenheim.............. 143
for Comet Barnard. By Dr. A. Krueger 144
panion" to The Observatory 144

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and T. Lewis, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpool nomical Societies; Articles by various eminent Astronomers, E American, and Continental; Correspondence on topics of interest con with the Science; Notes on the progress of Astronomy; Reviews o nomical publications; Ephemerides of comets, variable stars, S satellites, and for physical observations of the Sun, Jupiter, &c.; a the usual astronomical information.

Amongst the contributors to 'The Observatory' in 1885 were Pro Asaph Hall, Holden, Hough, Pickering, Pritchard, and Young Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs. Ba Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"— *Astronomique* (organ of the Paris Observatory).

CONTENTS OF No. 107.

Meeting of the Royal Astronomical Society on January 8, 1886 ....
Meeting of the Liverpool Astronomical Society ....

Articles:—

Large Telescopes v. Small. By Prof. C. A. Young, Ph.D., For. Assoc. R.A.
Observations of Nova Andromedæ. By Joseph Baxendell, F.R.S., F.R.A.
The Meteor-shower of Nov. 26–29, 1885. By Edwin F. Sawyer ....
The Chromosphere in 1885. By the Rev. S. J. Perry, F.R.S., F.R.A.S......

Correspondence:—

Proposed Maps for tracing Meteor-paths. By T. W. Backhouse, F.R.A.S...
Proposed Change in the Astronomical Day. By Sir Robert S. Ball, LL.D
Royal Astronomer of Ireland ....
The Meteoric Shower of Nov. 27. By H. J. Bell, F.R.A.S. ....
The Variable Star η Argûs. By W. T. Lynn, B.A., F.R.A.S. ....
Occultation-Cycle. By the Rev. S. J. Johnson, F.R.A.S. ....
Satellites of Jupiter. By Edmund J. Spitta, F.R.A.S. ....
Meteors with Shifting Radiants. By W. H. S. Monck ....
Hyginus N. By W. H. Wesley...............

Notes:—

A New Method of Determining the Amount of Astronomical Refraction.— The Pulkowa Observatory.—The Great Pulkowa Refractor.—Newton an his Niece.—Astronomical Prizes of the Académie des Sciences.—Th Double Star p Eridani.—New Observatory in Indiana.—Effect on th Earth's Motion produced by small Bodies passing near it.—Method o supporting a Mercury-trough for Reflection-Observations.—The lat Dr. J. C. Draper.—The R.A.S. Council.—Editorial Notes 10

Elements and Ephemeris for Comet Brooks 2. By Dr. H. Oppenheim...............
Ephemeris for Comet Fabry. By Dr. H. Oppenheim ....
Elements and Ephemeris for Comet Barnard. By Dr. A. Krueger...............

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 108. MARCH. 1886.

ANNIVERSARY MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, February 12, 1886.

E. Dunkin, F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel, Esq., and
Lieut.-Col. G. L. Tupman.

The Minutes of the last Anniversary Meeting and also those of the Special Meeting of May 8, 1885, were read and confirmed.

Mr. Knobel suggested that, as the scrutiny of the balloting-papers sent in by absent Fellows would occupy some time, the ballot should be taken before the reading of the Report.

Lord Crawford seconded the suggestion.

Capt. Noble thought that some provision ought to be made for the ballot remaining open long enough to allow Fellows who came in later to give their vote.

Mr. Knobel. Before the ballot commences I would point out that, in accordance with the alteration of the Bye-law made last year, the signatures on the envelopes have to be verified; and hence I would propose that the Assistant Secretary do attend the Scrutineers for the purpose of verifying these signatures.

After a few further remarks, the two proposals of Mr. Knobel were put to the Meeting and adopted.

The President appointed Sir J. Cockle, Mr. Lecky, and Mr. Inwards as Scrutineers.

Mr. Lecky. Suppose the ballot-paper is signed by the Fellow, is it to be passed by the Scrutineers?

Mr. Ranyard thought it would be a pity for papers to be refused on merely technical grounds; but he preferred that these points should be left to the judgment of the Scrutineers.

Mr. Knobel. When the alteration in the Bye-law was made it was decided, I believe, that it would be contrary to the spirit of the ballot; and any signature on the ballot-paper was considered inadmissible.

Col. Tupman. May the sheet be torn in half?

Capt. Noble. I think the Bye-law says any list may be received.

Ultimately it was felt that the Scrutineers should use their own judgment in the matter, and the ballot then proceeded, it being agreed that it should remain open till half-past four o'clock.

Mr. Criswick presented the Report of the Auditors, with a certificate stating that the books and instruments were in satisfactory condition so far as safe keeping was concerned.

The telescope lent to the Transit of Venus Committee was lost in the 'City of Brussels'; this had been replaced by the Committee with a 6-inch telescope by Grubb.

The Report was then read by the Secretaries. There were notes on the following points connected with the progress o Astronomy during the past year*:—

- *a.* Uranometria Nova Oxoniensis.
- *b.* Dr. Müller's Sidereal Photometry.
- *c.* Herr Wolff's Sidereal Photometry.
- *d.* The Cape Catalogue, 1850.
- *e.* Longitude Determinations.
- *f.* Eclipse Expedition to Caroline Island.
- *g.* Hill on Lunar Inequalities.
- *h.* Hall on the Orbits of Satellites.
- *i.* Bakhuyzen on the Rotation Period of Mars.
- *j.* Langley's Researches on Solar Heat.
- *k.* Stellar Photography.

These will be printed in the 'Monthly Notices.'

The President then delivered his address and concluded b presenting the medal of the Society jointly to Professor C. Pritchard, and to Dr. Huggins, Foreign Secretary, on behalf o Professor E. C. Pickering of Harvard College Observatory.

Prof. G. Forbes. I have now to move "That the Report of th Council now read be received and adopted, and that it be printe and circulated in the usual manner, together with the President' Address and the Report of the Auditors."

Mr. Brett. I have pleasure in seconding the motion.

The resolution was carried without discussion.

---

* [Most of the papers have been already reviewed in our pages.

For (*a*) see 'Observatory,' No. 106.
(*c*) (*i*) " " No. 104.
(*e*) " " Nos. 96 and 103
(*d*) " " No .92.
(*f*) " " No. 96.
(*g*) " " No. 108.
(*h*) " " No. 102.
(*j*) " " No. 101.—Editors.]

The President then called on Mr. Ranyard to move the resolution of which he had given notice:—"That Bye-laws 71 to 75*, both inclusive, and referring to the medal, be repealed."

Mr. Ranyard. The effect of the proposal I am about to make would be that no medal would, in future, be given by the Society. I am quite aware that in making such a proposal I am opposing the opinion prevalent amongst Scientific Societies. Our Society has awarded a medal almost since its own birth; and within the last ten or fifteen years many new medals have been instituted by different Societies. My proposition implies that this giving of medals is wrong in principle, and that it would have been better for Science had none been awarded. I have heard many reasons given for the retention of the principle, and I should like to hear others in its justification, for I think it lies with those who approve of medals to show that they tend to advance science, and are for the benefit of such a Society as ours. (No, no!) It is said that an opportunity is thereby afforded to discuss the work of others. Three meetings are devoted by the Council every year to the discussion of the work of those astronomers who have been proposed for the medal. This, no doubt, has a tendency to make certain Members of the Council carefully read up a few memoirs; but I query whether it is a sufficient consideration to warrant giving up three whole Council meetings. Then, again, it is said that medals do honour to those who have done work for Astronomy. (Hear, hear!) Perhaps so, but it is at a time when they do not want honour.

Mr. Pritchard. When is that?

Mr. Ranyard. When they have achieved it by their work, if it is properly done; for it is by a man's work that he will be judged and remembered. It is also said that medals are an incentive to work. This I question, and as there are several medallists in the room I should be interested to know from any one of them whether he did his work in order to get the medal. (A voice: Not one of them.) It is said that medals form a suitable commemoration. Our medal is not given in any name, and very few know anything about Copley, in whose name the medal of the Royal Society is given. I think such men can rest on their own merits and do not want extraneous advertisement. Then it is said that the giving of medals leads the way in science. But I question whether any one looking down the list of the Copley medallists will think that it marks out the history of science. With reference to awarding medals to specialists, I think no Council, however able, can really rightly judge between specialists, and they put themselves in a wrong position if they attempt to do so. Medal giving necessarily gives rise to the discussion of personal matters, and tends to lower the scientific spirit.

Mr. Esdaile. I beg to second the motion.

Mr. de la Rue. I stopped here especially to hear Mr. Ranyard's reasons for depriving the Society of the means of gracefully recog-

Hill on the Lunar Inequalities due to the Ellipticity of the Earth.

It is well known that M. Delaunay was unfortunately prevented by a premature death from completely carrying out his purpose of determining all the sensible inequalities of the Moon's motion by means of his very original and beautiful method of treating that subject. Happily the two magnificent volumes in which he determines the inequalities which are caused by the disturbing force of the Sun, on the supposition that the motion of the Earth about the Sun is purely elliptic, are complete in themselves. The small effects due to the action of the planets and the spheroidal figure of the Earth, as well as those which arise from the disturbances of the Earth's motion, remained to be determined.

Mr. G. W. Hill, who is already well known for his skilful treatment of special portions of the lunar theory, has, in the paper now to be noticed, produced a valuable supplement to Delaunay's work by applying the same method to the determination of the lunar inequalities which are due to the ellipticity of the Earth. This paper forms part 2 of vol. iii. of the valuable series of astronomical papers prepared for the use of the 'American Ephemeris' and 'Nautical Almanac.'

The author begins by developing the terms of the disturbing function which are introduced by the ellipticity of the Earth, by substituting for the Moon's co-ordinates their disturbed values as already given by Delaunay's work. Some idea of the length and complexity of this substitution may be formed when it is stated that the development so obtained contains one constant term accompanied by 121 periodic terms.

The next process is by a series of transformations of the variables involved gradually to remove these periodic terms from the disturbing function, so that it is at length reduced to the form of a constant term.

The number of such operations required to effect this reduction amounts to 103, although each operation is individually sufficiently simple.

By the essential principle of Delaunay's method the differential equations throughout these transformations always preserve their canonical form, and therefore when the disturbing function has been reduced to the above-mentioned simple form, the integrals are at once obtained.

In the next place the transformations indicated in the 103 operations above mentioned are also made in Delaunay's expressions for the three co-ordinates of the Moon, so that finally the values of these co-ordinates are found in terms of three arbitrary constants and three angles, each of which consists of a term proportional to the time joined to an arbitrary constant.

The co-ordinates thus expressed are the longitude, the latitude, and the reciprocal of the radius vector. As this last quantity is only intended to be employed in finding the Moon's parallax, it is given by Delaunay with much less precision than the other two co-ordinates, a circumstance which is to be regretted as an imperfection from a theoretical point of view.

The expressions thus found are purely analytical, that is the coefficients are expressed in series of powers and products of Delaunay's constants m, e, e', γ, each term also involving as a factor a constant quantity which depends on the figure of the Earth.

In order to make his work more complete, Mr. Hill determines the numerical value of this last-mentioned factor by a very elaborate discussion of the results of numerous pendulum experiments.

Finally, by the substitution of the known values of the constants employed, the numerical expressions for the perturbations of the Moon's co-ordinates produced by the figure of the Earth are obtained.

It will be remarked that comparatively few of the coefficients so found amount to an appreciable quantity, by far the larger number being utterly insensible.

The quantity m denoting, as in Delaunay, the ratio of the mean motion of the Moon to that of the Sun, it is found that the analytical expressions of most of the coefficients involve negative powers of m. This circumstance, which never happens in the case of the perturbations due to the Sun's action, has given rise to a difficulty in some minds as to the admissibility of Mr. Hill's results. Mr. Stockwell, in particular, in an article in the twenty-ninth volume of the 'American Journal of Science,' asserts that the value given to the coefficient of the principal equation of latitude leads to a manifest absurdity, and "justifies the suspicion that the entire solution is erroneous."

The difficulty thus noticed by Mr. Stockwell, however, admits of an easy explanation. He applies Mr. Hill's formulæ to a case in which they are not applicable, and for which they were not intended. The form of development in series adopted by Mr. Hill is founded on the supposition that the perturbations due to the Earth's figure which he wishes to determine are very small compared with those due to the action of the Sun, and therefore he expressely neglects quantities which are proportional to the square of the first-named perturbations. Now, in the case of our Moon, which is that treated by Mr. Hill, the above-mentioned supposition certainly holds good, and consequently his formulæ are sufficiently accurate.

If, however, the Sun's distance from the Earth were very much greater than it is, or if the Moon's distance were very much less than it actually is, then the perturbations arising from the Earth's figure might be much greater than those which arise from the Sun's action, and a different form of development would have to be adopted.

In this latter case it would be better to refer the motion of the Moon, not to the ecliptic, but to a fundamental plane passing through the line of intersection of the equator and ecliptic, and occupying a definite intermediate position between those two planes. If the perturbations due to the action of the Sun are much greater than those due to the Earth's figure, this fundamental plane nearly coincides with the ecliptic, whereas if the latter perturbations are much greater than the former, the fundamental plane nearly coincides with the equator. In Mr. Hill's formula, the principal term in the expression for the latitude nearly represents the distance of the fundamental plane from the ecliptic corresponding to the actual longitude of the Moon at the time.

A simple analytical illustration of the change of form of the coefficient of this term of the latitude in different circumstances may be given.

If m have its usual meaning as before stated, and if c be a small positive constant depending on the ellipticity of the Earth, then the value of the coefficient in question is approximately proportional to—

$$\frac{c}{m^2+c}.$$

Now, if, as in the case of our Moon, c is very much smaller than m^2, so that we may neglect the square of c compared with that of m^2, the quantity just mentioned becomes approximately $=\frac{c}{m^2}$; whereas if m^2 is small compared with c, the same quantity becomes nearly $=1$, and the coefficient becomes nearly independent of the ellipticity of the Earth, as it should do, since in this case the coefficient of this term is approximately equal to the sine of the obliquity of the ecliptic.

Mr. Stockwell's second objection, that Mr. Hill has omitted to take into account the modification of the Sun's disturbing force which is caused by the alterations of the Moon's coordinates due to the ellipticity of the Earth, seems to arise from a misapprehension on his part of the spirit of Delaunay's method. These alterations of the Moon's coordinates are implicitly involved in the variables a, e, γ, l, g, h, throughout the series of operations by which Delaunay gradually removes from R the periodic terms arising from the action of the Sun. J. C. Adams.

Maxima and Minima of Variable Stars.

I give in the following table the times of maximum or minimum of a small number of Variable Stars observed here in 1885, compared with the data of the Ephemeris which forms so useful a feature of the 'Observatory.' The maximum of U Cancri belongs to 1884, but I insert it for comparison with the Ephemeris date which falls in 1885. In the cases of R and S Scorpii, although my observations are not complete enough to give the times of maximum with precision, they suffice to show that the predictions of the ephemeris are pretty exact.

In column 2 M. signifies maximum; *m.* minimum.

Star's Name.	Max. or Min.	Observed.	Calculated.	C–O.	Mag.
o Ceti	M.	Feb. 11	Jan. 28	–14	2·9
S Canis Min.	M.	Jan. 20	Jan. 29	+ 9	7·4
U Cancri	M.	Dec. 30	Jan. 22	+23	10·6
R Ursæ Maj.	*m.*	Mar. 10	....	..	13·2
	M.	June 28	July 12	+14	7·1
S Ursæ Maj.	M.	May 5	Apr. 22	–13	7·2
	m.	Aug. 30	Aug. 13	–17	12·5
S Coronæ Bor.	M.	May 5±	Apr. 14	–21	7·6
R Scorpii	M.	May	May 11	..	..
S Scorpii	M.	April	Apr. 26	..	..
S Aquilæ *	*m.*	June 16	May 22	–25	11·0
U Cygni	M.	May 16	June 12	+27	7·7
T Delphini *	M.	Aug. 17	July 26	–22	10·3
R Vulpeculæ	M.	July 20	June 3	–47	8·2
T Cephei	M.	April 2	Feb. 25	–36	6·3
	m.	Sept. 15	....	..	9·6

Of Ceraski's short period variable U Cephei only two minima were obtained in 1885, viz.:—March 14, $9^h\ 32^m$, and March 19, $9^h\ 12^m$, both of which were low minima, mag. 9·45. The prediction of the ephemeris for the second minimum was $8^h\ 55^m$, 17^m earlier than the observed time. The agreement with the times deduced from my own elements, given in the 'Observatory' for June 1884, is even closer, the differences, C – O, being 0^m and -1^m respectively.

It will be noticed that in the case of T Cephei the ephemeris time of maximum is 36 days earlier than the observed time. A comparison of the predictions for 1885 and 1886 would seem to suggest that this difference is due rather to the adopted epoch than to the period. As I have now observed consecutively four maxima and five minima of this star, I am induced to send you the results of a discussion of the observations I have obtained.

Observed times of Maxima.	Observed Magnitude.
1882, January 13	6·4
1883, February 6	6·3
1884, March 7	6·7
1885, April 2	6·3

---

* T Aquilæ and S Delphini in the nomenclature of Mr. Baxendell, their discoverer.

Observed times of Minima.	Observed Magnitude.
1881, June 18	9·5
1882, July 23	9·8
1883, August 23	9·9
1884, August 15	9·7
1885, September 15	9·6

Forming equations and solving, we get from the four maxima:—

Period 392·0 days. Epoch 1884, March 6;

and from the five minima:—

Period 385·4 days. Epoch 1883, August 7.

If, with these elements, we calculate the times of maxima and minima respectively and compare them with the observed times, we obtain the following residuals:—

C–O Maxima.	C–O Minima.
–1·0	+ 9·2
+2·0	– 5·4
–1·0	–16·0
0·0	+11·4
	+ 0·8

These numbers indicate a much greater regularity in the sequence of the maxima than of the minima. It is true that I have unfortunately been unable to follow the star at minimum quite so closely as at maximum; but I hardly think that the irregularities can be apparent only, and due entirely to this cause. The interval from minimum to maximum would seem on the whole to be longer than that from maximum to minimum; and on the rising curve, about 100 to 120 days after minimum, there appears to occur a slackening for a time in the upward movement. The star has a fine spectrum, with dark bands of considerable intensity. Unfortunately it has apparently escaped the notice of M. Dunér, as it is not found in his memoir, "Sur les Etoiles à Spectres de la troisième Classe."

As calculated from my elements, the maxima and minima of T Cephei in the years 1886 and 1887 will fall as follows:—Maxima: 1886, April 29; 1887, May 26. Minima: 1886, October 6; 1887, October 27.

Knowles Lodge, Cuckfield,
1886, Feb. 16.

GEORGE KNOTT.

---

*On the Variable Star T Aquilæ**.

$(1855{\cdot}0\colon\ \alpha\ 20^{h}\ 4^{m}\ 57^{s},\ \delta\ +15^{\circ}\ 11'{\cdot}5.)$

DURING the year 1884 I observed two maxima and two minima of this variable, but they differed so widely from the calculated results that I did not think it desirable to include them in my list of maxima and minima published in the May 1885 No. of the 'Observatory' until I had re-examined all my observations of this star, and combined the results with those obtained by other observers, in order to ascertain, as far as possible, whether it had previously exhibited similar abnormal changes.

---

* [This star is called S Aquilæ by Schönfeld, whose nomenclature we have followed in the 'Companion.' Mr. Knott also, in the preceding article, gives the same letter to the star. EDITORS.]

From fourteen maxima observed by myself, nine by Dr. Schönfeld, and two by George Knott, Esq., between October 1863 and November 1883, I have obtained 146·536 days as the value of the mean period; and from thirteen minima observed by myself, seven by Dr. Schönfeld, and one by Mr. Knott between August 24, 1863, and September 7, 1883, 146·563 days.

The mean difference between the observed and calculated times of maximum is 7·791 days, and the greatest 26·180 days; and the corresponding differences of the times of minimum are 6·175 days and 15·270 days—the irregularities in the times of maximum being therefore much greater than those of minimum.

The maxima I have observed since November 1883 are:—

1884, July 11.
Nov. 25.
1885, Aug. 18.
Dec. 25.

And using the above period of 146·536 days, the differences between the observed and calculated times are:—

C – O.
+ 72·508 days.
+ 82·044 „
+ 109·116 „
+ 126·652 „

The minima observed since September 7, 1883, are:—

1884, Sept. 11.
Dec. 21.
1885, June 10.
Oct. 2.

And with a mean period of 146·563 days the differences are:—

C – O.
+ 84·049 days.
+ 129·612 „
+ 105·175 „
+ 137·738 „

These results show that about the end of 1883 a remarkable disturbing influence came into operation, suddenly and materially reducing the length of the star's period, which has since been subject to great and very unusual irregularities, the shortest single period being 101 days and the longest 171 days; and this has occurred without materially affecting the mean magnitudes at maximum and minimum.

The mean magnitude at maximum, from the whole series of observations, is 9·09, and at minimum 11·02; the mean range of variation is therefore 1·93 mag. The highest maximum magnitude is 8·4, and the lowest minimum is 11·7, the extreme range of variation being therefore 3·3 mag.

The mean length of the interval from minimum to maximum is 74·790 days, and from maximum to minimum 71·759 days; but these intervals are subject to very considerable changes; thus up to the end of 1883 the shortest interval from minimum to maximum was 51 days, and the longest 90 days; while the shortest from maximum to minimum was 50 days, and the longest 78 days; but since 1883 three intervals from minimum to maximum give a mean of 76 days with extreme values of 69 and 84 days, and three from maximum to minimum give a mean of 44·3 days with extreme values of 26 and 62 days, thus showing that the shortening of the period has been mainly due to a shortening of the interval from maximum to minimum. JOSEPH BAXENDELL.

The Observatory, Birkdale, Southport,
1886, February 8.

The Variable Star S Vulpeculæ.

FROM a projection of a series of observations of this variable made by my father since 1862, I have obtained the following dates of maxima and minima:—

Maxima.

No.	Date.	Mag.
1.	1863, September 8.	8·85
2.	November 21.	9·05
3.	1864, June 13.	8·95
4.	August 12.	8·95
5.	October 28.	8·9
6.	1865, July 20.	9·1
7.	October 2.	9·15
8.	1866, June 12±.	9·0
9.	August 27.	8·95
10.	November 8.	8·95
11.	1867, October 15.	9·0
12.	1868, May 1.	9·1
13.	July 15.	9·05
14.	November 15.	9·0
15.	1884, October 7.	8·9
16.	December 13.	9·0
17.	1885, July 1.	9·2
18.	September 11.	9·1
19.	November 20.	8·9

Minima.

No.	Date.	Mag.
1.	1863, October 30.	9·65
2.	1864, May 16.	9·7
3.	July 22.	9·55
4.	September 30.	9·75
5.	December 10.	9·7
6.	1865, April 24.	9·75
7.	June 30.	9·6
8.	September 14.	9·7
9.	1866, May 17±.	9·8
10.	October 18.	9·8
11.	December 23.	9·6
12.	1867, September 30.	9·6
13.	December 2.	9·7
14.	1868, April 7.	9·8
15.	June 17.	9·6
16.	1884, September 19.	9·8
17.	November 21.	9·95
18.	1885, June 12.	9·8
19.	August 20.	9·7
20.	October 30.	9·75

Dividing the maxima into two groups, and treating by the method f least squares, I obtain from the 1st group (*i. e.* Nos. 1 to 14 inlusive)—

Mean Period = 67·71 days,
Epoch = 1866, February 8·56;

nd from the second group (Nos. 15 to 19)—

Mean Period = 67·97 days,
Epoch = 1885, April 27·8.

Treating the minima in the same manner, the 1st group (Nos. 1 to 15) give—

Mean Period = 67·81 days,
Epoch = 1867, January 18·65;

nd the second group (Nos. 16 to 20) give—

Mean Period = 67·69 days,
Epoch = 1885, April 7·5.

The mean period of the variable therefore, as derived from the above four determinations, is 67·795 days.

The mean difference between the calculated and observed times of maxima in the first group is 4·26 days, and the greatest difference 11·99 days, and in the second group 1·50 and 3·70 days respectively. In the first group of minima the mean difference between the calculated and observed dates is 3·97 days, and the

greatest difference 17·75 days, and in the second group 2·04 a
2·60 days respectively.

From the above it will be seen that the differences are much le
in the second groups than in the first groups; this is partly owi
to the fact that the maxima and minima in the second series ha
been better observed than those in the first series, and part
because the period was undoubtedly more irregular from 1863
1868 than it has been from 1884 to 1886.

An examination of the differences between the calculated an
observed dates of both minima and maxima shows that the peric
had, on the whole, undergone no sensible change from 1863
1868. From a few observations between 1868 and 1884 it seem
probable that it became very slightly shorter after 1868; it ha
however, now, according to the second groups, again assumed it
original length.

The mean interval from minimum to maximum is 20·60 day
and from maximum to minimum 47·19 days; this star therefor
belongs to the class of variables in which the increase of brightnes
is much more rapid than the decrease.

The mean magnitude at maximum is 9·01 and at minimum 9·72
the *mean* range of variation is therefore 0·71 mag. The highes
magnitude observed is 8·85 and the lowest 9·95; hence the *extrem*
range of variation is 1·10 mag.

The Observatory, Birkdale,
Southport. 1886, Feb. 8.

JOSEPH BAXENDELL, Jun.

History of Astronomy in the Ninteenth Century.*

THERE is always an especial pleasure in seeing a strong and skilful worker engaged on a worthy and congenial task, and that pleasant spectacle is abundantly afforded by the book before us. The rapid and extraordinary progress of astronomy during the present century had struck Miss Clerke as lending itself with facility to untechnical treatment, and as, to use her own expression, it had "thus become practicable to describe, in simple language, the most essential parts of recent astronomical discoveries: being practicable, it could not be otherwise than desirable to do so." For this purpose she has preferred the historical form, as setting forth not merely *what* we know, but also *how* we came to know it; and her complete success more than vindicates her choice of a theme and her manner of treating it. The book she has produced will be full of interest to the general reader, for the history of the marvellous discoveries made in astronomy during the past hundred years is told in a felicitous and attractive manner: but it will not be less highly valued by the student and the astronomer, on account of its completeness and accuracy, and the really remarkable skill with which the leading points on which our knowledge has been increased in each subdivision of our science are seized upon and set forth. For reading and for reference it will be found equally admirable.

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* 'A Popular History of Astronomy during the Nineteenth Century.' By Agnes M. Clerke. Edinburgh: Adam and Charles Black, 1885. 468 pp.

The work is divided into two parts. Of these the first deals with the Progress of Astronomy during the First Half of the Nineteenth Century; and the foundation by Sir W. Herschel of sidereal astronomy and its subsequent development form the leading subjects. A happy instinct has led the authoress to give a biographical turn to this portion of her work, and the effect of the charming little sketches she has here woven into her story of Sir W. Herschel, Bessel, Fraunhofer, and others is very pleasing. The progress of our knowledge of the Sun up to the eclipse of 1851, the planetary discoveries of this period, especially that of Neptune, the progress in cometary astronomy, and the improvements in instruments occupy the third to the sixth chapters.

The second and larger part of the work deals with the Recent Progress of Astronomy, especially with solar physics and the discoveries of the spectroscope. This is at once the part of the book which was most required, and it is the one in which the authoress is most entirely at home. The chapters on Recent Solar Eclipses, Spectroscopic work on the Sun, and on Comets, are of especial value. Just such a collection of observations and summary of the results derived from them as are here given were much needed. Here and throughout the book the authoress writes with the decision and confidence of one who is well acquainted with her subject, and is not afraid to think for herself and announce her own decision. Thus, for example, the connection of sun-spots with planetary configurations on the one hand and with terrestrial meteorology on the other, is handled without undue credulity or scepticism; Prof. Hastings' coronal theory is summarily dismissed; Lockyer's "*basic*" lines are very carefully discussed, with a leaning, which will be now generally sympathized with, to an adverse decision, and Draper's claim to have discovered the bright lines of oxygen in the solar spectrum is accepted. In these and in many other similar cases the evidence on both sides is summed up briefly with great skill and fairness.

Besides the chapters above mentioned, others deal with the Temperature of the Sun, its Distance, the Planets and their Satellites, Planetary Evolution, and Stars and Nebulæ. The second part concludes, as did the first, with a notice of the improvements made in instruments. In the chapter on Stars and Nebulæ, Vogel's theory as to the types of stellar spectra and his alteration of Secchi's nomenclature is freely criticised. This chapter and that on Planetary Evolution are less satisfactory than the bulk of the book, the former being somewhat unduly curtailed; no mention, for example, is made of Dembowski's observations of double stars; but the defects in either case are of the slightest. The chapter on the various methods of determining the solar distance, on the other hand, is particularly well written.

Though the book covers so wide a field and covers it so we that nothing of really first importance is omitted, it can scarcely called a large book, the admirable condensation which has take place being due partly to judicious arrangement, but chiefly to th terse and epigrammatic style in which Miss Clerke writes. Scarcel a page but affords an example of some pithy and striking expressio Thus on p. 3 the authoress tells us that "observation is the pitile critic of theory," and on p. 172 refers to "the differences in likene which are always an earnest of increased knowledge." Then, agai we are reminded, p. 437, that "for every triton sun there a doubtless swarms of minnows," whilst from time to time we mee short and striking definitions like the following, p. 252, "the ter 'element' simply expresses terrestrial incapability of reduction. To this terse and vigorous style it is largely owing that the boo is so entirely interesting from beginning to end; there is n attempt at grandiose or sensational writing, the facts are allowe to have their own weight, the only effort made being to presen them as fairly and as briefly as possible.

A very valuable feature of the book, to the student almost th most valuable, is the numerous references to the original paper from whence the facts have been derived, the authoress havin endeavoured throughout to take as little as possible at second-hand.

Miss Clerke does not herself seem to have had an observer' training. There are several little hints of this to be noted here and there. Thus, p. 216, we are inferentially told that grea dispersion is needed to see the prominence spectrum, and the opinion expressed on the "Large *versus* Small Telescopes" controversy is, we venture to think, scarcely that of most observers, and exceeds even Mr. Denning's contention. But these and some similar criticisms which might be passed are of details only, usually of insignificant details. Considered as a whole, Miss Clerke's book deserves nothing but the most hearty praise; it has been most conscientiously and skilfully prepared, and well deserves a place beside Prof. Grant's 'History of Physical Astronomy,' to which it will form an admirable supplement. E. W. MAUNDER.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

A probable Ancient View of the Solar Corona without an Eclipse.

GENTLEMEN,—

In Dr. Huggins's most interesting paper "On the Corona of the Sun," forming the Bakerian Lecture for last year, he suggests that, in consequence of a slow secular diminution in the extension and brightness of the corona, as the Sun slowly loses heat and the actions of the photosphere become less fervent, it may not only have been much more extended and brilliant in early geologic time, but may even "have been still faintly visible in the earliest ages of the human race." And at the head of the paper he quotes a passage from the Life of Apollonius of Tyana by Philostratus, which has been quoted before as having been supposed to relate to the appearance of the corona during a total eclipse of the Sun, but which Dr. Huggins, by quoting in this connection, attributes, I presume, to a visibility of the corona in a particularly clear sky when there was no eclipse. The passage is as follows: speaking (viii. 23) of the time when Apollonius was teaching philosophy in Greece, not long before the death of the Emperor Domitian, Philostratus continues:—

ἐπεῖχε τὸν οὐρανὸν διοσημεία τοιαύτη τὸν τοῦ ἡλίου κύκλον περιελθὼν στέφανος ἐοικὼς ἴριδι τὴν ἀκτῖνα ἠμαύρου.*

Prof. Grant quotes the passage in *Ast. Nach.* No. 1838 (Vol. lxxvii. p. 223), with the remark: "It appears to me that the words here quoted refer beyond all doubt to a total eclipse of the Sun, and thus the phenomenon seen encompassing the Sun's disk was, really as well as verbally, identical with the modern corona." And he further suggests that Plutarch, in a passage which undoubtedly refers to the phenomena seen during eclipses, alluded especially to the same total eclipse as that supposed to be described by Philostratus. Mr. Chambers also ('Descriptive Astronomy,' 3rd edition, p. 186) assumes that the passage refers to a total eclipse of the Sun, and interprets the last clause as meaning "it [*i. e.* the corona] appeared coincidently with the total obscuration of his light," a rendering which, I submit, the words will not bear. He also precedes his reference to it by the statement (which, however, I cannot find in Philostratus) that "the death of the Emperor Domitian had been 'announced' previously by a total eclipse of the Sun."

It is rather curious that so many should have quoted the passage as referring to such an eclipse without ascertaining whether one occurred about the time of which Philostratus was writing. Herr F. K. Ginzel, however, in his recent elaborate and interesting 'Astronomische Untersuchungen über Finsternisse,' has not failed to discuss this point, and to show that, as a matter of fact, no total eclipse of the Sun was visible in Greece during the two years in which Apollonius resided there, not long before the assassination of Domitian, which occurred on the 18th of September, A.D. 96, when Apollonius (as, to use a phrase now common, "every intelligent schoolboy knows") was at Ephesus. An eclipse indeed occurred on the 21st of May, A.D. 95, but its principal scene was China and the farther India; it was a very small partial eclipse in Western Asia, and not visible in Greece. "Das in Rede stehende Phänomenon," therefore concludes Herr Ginzel, "mag wie immer gedeutet werden eine Erklärung desselben als Sonnenfinsterniss ist von Seite d Rechnung ganz unzulässig." I must confess it seems to me th the language of Philostratus does not read like a description of eclipse. It is quite true that he goes on to say that the Procons of Achaia, alarmed at the phenomenon, sent for Apollonius fro Athens, where he then was, to Bœotia, having heard that he w skilful in divination, and told him that he feared all things wou be turned into night; to which Apollonius replied, *θάρσει, ἔσται γ τι ἐκ τῆς νυκτὸς ταύτης φῶς.* But the Proconsul was evident dreading the phenomenon simply as a presage, and the night spoke of was probably a metaphor for political convulsions, whi Apollonius intended to assure him would be transient. At ar rate, it is clear that no eclipse occurred at the time in questio and it seems to me that it is exceedingly likely that the phenomen was a manifestation of the corona in a very transparent state the atmosphere without an eclipse. Yours faithfully,

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* In the Bakerian Lecture, by a singular misprint, this word (the corona) is quoted as *στέφαρος*.

Blackheath, 1886, Feb. 3. W. T. Lynn.

Proposed Change in the Astronomical Day.

Gentlemen,—

In answer to your invitation to give my opinion on the 6 resolution of the Meridian Conference at Washington, I would a for space in your Journal for the following remarks.

The difficulties and inconveniences with which astronomers w have to contend if they adopt the proposed change in the astr nomical day have been strikingly set forth by Professor Newcom in a paper in the 'Month. Not.' (Jan. 1885), in a letter to the la Superintendent of the Naval Observatory ('Nature,' July 16, 1885 and in a speech at the congress at Geneva ('Vierteljahrsschrif xx. p. 228). It is impossible to add anything to the weigh arguments of Prof. Newcomb, but there is one part of the questi which appears to me not to have been sufficiently discussed. W is to benefit by the change, and who has hitherto suffered by t astronomical day being different from the civil day? Is it t general public, of whom 99 per cent. have lived in blissful ignoran of the existence of an astronomical day? Or is it the navigato But if a sailor is intelligent enough to learn how to navigate h ship and use an ephemeris, surely he does not require any ext amount of intelligence to learn that the day begins at Noon. B even supposing that sailors were liable to be confused in th respect, why not add in every place in the Nautical Almanac, whe the words "Mean Time" or "Apparent Time" occur, the wor "the day commencing at Noon"? If this were done, it would impossible for any one to make a mistake.

The editors of the 'Berliner Jahrbuch' and the 'Astronomisc Nachrichten' have joined the editor of the 'American Ephemeris' declaring against the proposed change; and as many other i fluential astronomers have done the same, there is at present chance whatever of the new system being adopted even by majority of astronomers. It seems therefore at all events necessary to postpone its introduction for at least ten years, and if there then seems more chance of unanimity in the matter, the change might commence with Jan. 1, 1901. Yours truly,

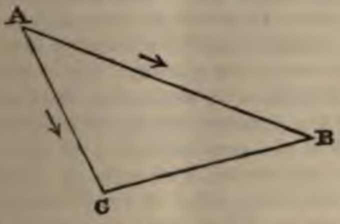
Armagh Observatory,
Feb. 6, 1886.

J. L. E. DREYER.

Trained Meteors.

GENTLEMEN,—

Professor Fitzgerald has suggested to me a test of the views which I have recently been advocating in your columns with regard to the participation of meteors in the motion of the atmosphere. Many of these meteors are accompanied or followed by streaks or trains. These streaks or trains consisting chiefly of heated air (with the possible addition of vaporized portions of the meteor) undoubtedly partake in the motion of the atmosphere; and therefore if the meteor does *not* so participate, its path will not be in the same direction with its streak or train. To show this by a simple diagram:



Let the meteor become visible at A and cease to be visible at B, describing the line AB during its visible career. Let AC represent in magnitude and direction the Earth's motion during the time that the meteor requires to travel from A to B. Then when the meteor disappears at B, its train will be in the line BC, not the line AB. And as the Earth's velocity is often considerable when compared with that of the meteor, this shifting of the train ought to be easily perceived.

Having consulted two of the greatest authorities on the subject in this kingdom, Mr. Denning and Col. Tupman, I think I can safely say that no such shifting in the position of the train has been observed. In the case of very long-enduring trains indeed some shifting has been noticed, but apparently not more than strong air-currents would account for. With streaks or trains of shorter duration there was no deviation at all.

The conclusion would appear to be that trained meteors partake so fully in the motion of the atmosphere that the spectator sees them exactly as he would do if the Earth was motionless (excepting that, of course, in that case the *velocity* of the meteor would be different) and that the observed radiant-point is the true radiant without any correction for the Earth's motion. The same remark will probably be found to hold good for the majority of meteors but there may be some exceptions. Yours truly,

Dublin, 1886, Feb. 13. W. H. S. MONCK.

The Wedge Photometer.

GENTLEMEN,—

My criticism of the Wedge Photometer in the 'Sidereal Messenger' for November was not intended to apply to any particula instrument or observations, but to the theory, and to call attentio to a source of error to which observations to be made with a wedg might be liable, arising from differences of illumination.

A complete wedge, coming to an absolutely sharp edge, woul measure the faintest stars visible with the full aperture, the illumination being that of the unobstructed field at the sharp edge, an gradually becoming less as the wedge becomes thicker. For th first magnitude from the sharp edge, with a low magnifying-powe the difference of illumination, if neglected, would introduce important errors in the results. For each succeeding magnitude th errors would become much less. The description of Prof. Pritchard's wedge in the 'Observatory' for January shows that i begins more than 3 inches from the absolutely sharp edge, so that i requires more than twice the aperture that a sharp wedge of th same length would require in measuring the same stars; but fo bright stars, where the difference of aperture is unimportant, it ha the advantage that at the very beginning of the wedge it cuts o four-fifths of the illumination, and perhaps much more than tha proportion of the disturbing effect of the illumination.

Prof. Pritchard claims that average moonlight, when reduced b the wedge to one-eighth (this is my deduction from his figures ceases to affect the results. This may be; and at the same tim even the ordinary sky illumination, with a wedge fitted to measur the faintest stars visible in a large telescope, may produce a appreciable error in the resulting magnitudes of those faintes stars, unless the amount of the disturbing effect is ascertained an the proper correction applied. While it is better, when it can as we be done, that larger apertures should be employed, so as to avoi the necessity for the correction, it is desirable that small telescope should be available for such observations, and important that th necessity for the correction in that case should not be overlooked.

By referring to my observations made to determine the amoun of extinction caused by illumination, I find that the effect of th wedge, at the point where Prof. Pritchard states that average moonlight is extinguished, is just sufficient to reduce the light of th Moon and the sky combined, at the first or third quarter, to th light of the sky alone without the wedge. Comparing with th black sky of the thick part of the wedge, according to those observations, the approximate extinguishing effect of the light of th full Moon would be at the same point ·25 mag.; 2 days before, ·20

4 days before, ·10; and at the quarters, ·05 magnitude; which would lead to the conclusion that it is only in measuring telescopic stars in a bright moonlight that the effect would be appreciable with his instrument. Yours, &c.,

New York, 1886, Jan. 25. HENRY M. PARKHURST

The Comet of 1812 (*Pons-Brooks*) *in* 1884.

GENTLEMEN,—

The low altitude of the comet as seen from this country was very likely the reason that no British observation of the triple tail seen by Mr. Barnard at Nashville, Tenn., on January 21 1884 ('Observatory,' Vol. viii. p. 325), has been published.

I saw the comet on that night, but not very favourably, owing to passing clouds, and perceived no difference in its appearance from that on the previous evening, when the southern side of the tail was much the brightest, best defined, and longest, the northern side extending but a short distance. With naked eye, the tail reached to ι Ceti, but I could not see there was any bifurcation.

The next good view I obtained of the comet was on the 25th at 6.45 G.M.T.; it appeared much the same as on the 20th, the tail reaching to a point equidistant from β and η Ceti, as seen with naked eye; and I suspected it as far as η.

On all three evenings I also made use of a binocular field-glass of 2·05 inches aperture, power about 4, without seeing any branching of the tail. T. W. BACKHOUSE.

Sunderland, 1886, Jan. 27.

The Council of the Royal Astronomical Society.

GENTLEMEN,—

'The Observatory' has wisely and honourably abstained from the controversies which have afflicted the Royal Astronomical Society, and I do not now propose to revive them. Without so doing, I think I may venture to express the deep personal regret, not unmingled with a sense of shame, which many of us feel at the rejection of Dr. De la Rue's name from the list of the Council. It is impossible that such can have been the deliberate wish of the majority of the Society.

Among all its members there is not one who has more highly adorned the highest forms of amateur astronomy than Dr. De la Rue; neither has there been one among us more acceptable as a colleague, wiser in counsel, or influential in action. He also formed an important link between us and the other scientific societies.

In years gone by the Society benefited by his admirable and single-minded services as Honorary Secretary and as President. Externally to the Society, he by his munificence and counsels contributed mainly to the establishment of the Observatory in Oxford, and for a time to its maintenance. I might add more, but I fear that even what I have felt impelled to urge will not be personally acceptable to Dr. De la Rue, who has rather conferred than received honour by acting on the administration of the Society.

Yours truly,

Oxford University Observatory. C. Pritchard.

NOTES.

Austrian Observatories*.—Of the 19 observatories at present in the Austrian empire, 10 may be considered as belonging to the state, 5 private, and 4 to the religious orders.

Royal Observatories.

At Vienna is *the* Royal Observatory, where is to be found one of the largest refractors in the world. This instrument, which is 27 inches aperture, has recently been erected and has been used by Prof. Vogel for spectroscopic observations of faint stars. The systematic search for small planets is carried on with a 12-inch refractor. Another work of the Vienna Observatory is the computation of the elements of comets after their discovery.

The other observatory at Vienna is at the Royal Polytechnic and is used only for geodetic and show purposes. The University of Graz has an observatory fitted with a 6-inch and several smaller instruments; but its unfortunate position prevents its usefulness.

At Prague, Prof. Weinek deserves the greatest credit for every work he has managed to get out of his observatory. He has a 6-inch, mounted on a staging and without a movable dome, so that he can only observe two hours either side of the meridian, and then only such objects whose altitude is less than 55°. The observatory attached to the University at Krakau appears to serve for purely teaching purposes. The marine observatory at Pola was, under Dr. Palisa, one of the most active in Europe. Besides the well-known 6-inch of asteroid fame, there is a 7-inch meridian-circle by Simms and a 12-inch reflector. The present Director wishes to occupy himself with celestial photography.

At the Marine Academy in Trieste there is an observatory principally employed in timing and regulating chronometers. It has a 3½- or 4-inch equatoreal. Besides these there are three other observatories, viz. the Royal Polytechnic and Central Meteorological, both at Budapest. The former has a 5-inch and the latter a 4-inch refractor. No work has been done. The third, at the University of Klausenberg, exists more on paper than in reality.

Private Observatories.

The largest and best fitted private observatory is that of O'-Gyalla, in Hungary. This astro-physical observatory was founded and is used by Dr. Konkoly. There are in use there refractors of 13 and 6 inches aperture respectively, and a large collection of spectral and kindred apparatus. The failing health of Dr. Konkoly lessens the output of the observatory, through which the name of Hungary has become known in the astronomical world.

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* From 'Sirius.'

The astro-physical observatory at Herény belongs to E. von Gothard. He has a good reflector with excellent clockwork, and also a fine 4½-inch refractor. The work done by M. Gothard is extraordinary; his chief time is taken up by celestial photography and spectroscopic observations of stars.

The private observatory of Herr Oppolzer at Vienna has a 7-inch and a 4-inch, and has done good work in former years in observations of asteroids and newly discovered comets. At the present time its condition is not so good as could be wished. Herr Oppolzer is prevented by other work from taking astronomical observations.

Herr Kufner, a banker of Vienna, has completed an observatory at Bau. The plan of work with his 10-inch refractor, mounted by Repsold, is not yet known.

A yet finer observatory has just been founded at Kis-Kartel by Baron Podmaniczky. The principal instrument is a 7-inch refractor by Merz, with a mounting by Cooke. The work commences next year with physical observations of the Sun, Moon, and planets, and also double-star measures.

Episcopal Observatories.

Among these that of Kalocsa takes the first rank. It is known to possess a splendid 7-inch with clockwork by Merz and also a 4-inch. The direction of this observatory was at first entrusted to a sick old man who wanted to do every thing, and the result was *nil.* The present director observes sun-spots in a different manner to astronomers at Potsdam, O'-Gyalla, and Zurich.

Amongst the old instruments in the observatory at Karlsburg is a fine 3-inch meridian-circle.

Erlau is a renowned observatory in the eyes of common folk, for on the titlepage of Kalendars one reads "Computed for the latitude of x by Prof. Dr. F. A. von M., Director of the Episcopal Observatory at Erlau. No observations have ever been made there.

The observatory at Kremsmünster belongs to the Order of Benedicts and reached its zenith under the direction of Father Strasser. One can truly say that the most worthy Father worked miracles with his small instrument (5-inch) and observed every phenomenon within its power.

A NEW OBSERVATORY IN HUNGARY.—Baron Podmaniczky and his wife have had erected an observatory on their estate at Kis-Kartel, near Budapest. The observatory is fitted with a 7-inch achromatic with its full complement of eyepieces and a Zollner spectroscope, besides two smaller instruments of $3\frac{1}{2}$ and 2 inches, the former being mounted as a comet-seeker. The observatory will be devoted to physical observations of Sun, Moon, and Planets, and Comets, as well as observations of double stars and nebulæ. Dr. Konkoly has superintended the fitting out of the observatory.

STABILITY OF SATURN'S RINGS [*].—Laplace has shown that the stability of Saturn's ring depends on the condition that it should be subdivided into a number of concentric rings with different velocities of rotation, so that even if observation did not enable us to substantiate this view, the theory of gravitation is sufficient to demonstrate it. More recently Tisserand has confirmed Laplace's result, and shows that a single ring could exist only if the density of the ring were considerably greater than that of the planet, and has calculated the maximum breadth of each elementary ring in terms of its density and mean radius.

Starting from the proposition that each elementary ring must be smaller as its density is less, M. Poincaré proceeds to show, in the paper before us, that if the density falls below a certain limit, any fluid ring is unstable whatever its size may be. Under the influence of the least perturbation the ring is not only subdivided into several concentric rings, but breaks up into a number of small satellites. The numerical result at which M. Poincaré arrives is, that if the rings were fluid and moved as a whole, the density of the interior ring should be at least one-fifth, and that of the exterior ring at least one-sixteenth of that of the planet. Maxwell estimated that a ring composed of small particles could be stable only if its mean density were *at most* equal to one three-hundredth of that of Saturn [†].

As the volume of the system of rings, assuming its average thickness to be about 0″·01 at mean distance, is only $\frac{1}{500}$ that of the planet, its mass on this estimate cannot exceed $\frac{1}{150,000}$ that of the planet. The attempts to determine the mass of the ring system from observation have not hitherto been satisfactory. Bessel found *m*, the reciprocal of the mass, as 118, Meyer as 1960. By a misprint in the 'Observatory,' Vol. vi. p. 279, this latter value is given as 119·1.

HALLEY'S SOUTHERN CATALOGUE.—With reference to his letter on this subject in the 'Observatory' for December 1885, Mr. Lynn desires to correct the suggestion he there made that Halley's name was omitted from the titlepage of the catalogue by Flamsteed's orders. "The 'Historia Cœlestis' was not actually published until 1725, nearly six years after the death of Flamsteed, who died before the second volume was quite completed. The remainder of

[*] Bulletin Astronomique, Tome ii. p. 507.

[†] By a slip M. Poincaré states that Maxwell made this estimation with regard to "un anneau fluide."

that volume and the whole of the third were finished under the care and superintendence of Joseph Crosthwait, assisted by Abraham Sharp, who corresponded with him from Little Horton, his native place." Mr. Lynn further shows, by extracts from Crosthwait's letters to Sharp (published in Baily's 'Flamsteed'), that the entire responsibility for the omission of Halley's name rests with Crosthwait.

THE WASHINGTON OBSERVATORY.—Commodore Geo. E. Belknap, U.S.N., Superintendent of the U.S. Naval Observatory, has issued his Annual Report, dated Oct. 5, 1885. During the year the 26-inch Equatoreal has continued in charge of Prof. A. Hall, who has been employed in observing the Satellites of the large planets and in observation of double stars. The observations of the Satellite of Neptune and those of the two outer Satellites of Uranus have been discussed, and the results published. A discussion of all the observations of Iapetus is now finished and has been recently published. The instrument and its subsidiary apparatus are in good working order, and the dome, 43 feet in diameter, is now revolved with great ease by means of the 4 horse-power gas-engine which has been connected with it. The Transit-circle, in charge of Prof. Eastman, has been employed in the observations of:—(1) Stars of the American Ephemeris; (2) The Sun, Moon, and major and minor planets; (3) Miscellaneous Stars. Since the last report 5520 observations have been made, including 90 of the Sun, 70 of the Moon, and 56 of the major planets, and 64 of the minor planets. The 9·6-inch Equatoreal was in charge of Commander Sampson and Prof. Frisby. The work of the instrument has been confined to observations of comets and asteroids and of occultations of stars by the Moon, as well as the verification and correction of doubtful observations of stars and asteroids made with other instruments. The work of reducing the observations made with the Prime Vertical Instrument in 1883–84, for the determination of the constant of aberration, has been pursued. Preparations have been made for carrying out the projected scheme of observations with reference to the problem of change of latitude with this instrument in conjunction with the Lisbon Observatory. The various phases of the annular eclipse of the Sun of March 16, 1885, were observed and 99 photographs were taken with the photographic apparatus of the Transit of Venus Commission. The Chronometers and Time Service Department, under Lieut. Pendleton, appears to be in a very efficient state. There are at present 240 chronometers at the Observatory for various purposes. The total number of time-balls now dropped by the Observatory signal is eight.

Commodore Belknap points out how desirable it is that the work of taking Sun photographs daily should be inaugurated as soon as possible. Such work, if pursued systematically and continuously, would put the Naval Observatory on a footing, in this regard, more nearly equal to that of the larger foreign Observatories. The Superintendent also renews the recommendations of his predecessors for the removal of the Observatory, at an early day, to the new site selected and purchased for such purpose in 1881. The present location is unhealthy in the extreme, and those who are called upon for night service suffer more or less from malaria a good part of the time. Fogs also, gathering over the Potamac at certain seasons of the year, frequently obstruct the observers, and many desired opportunities for astronomical work are lost in consequence. In the programme of work to be carried out at Washington during the current year, recently issued, we note that it is proposed to commence observations of variable stars with the 9·6-inch equatoreal. A photometer for this instrument has been ordered from Alvan Clark and Sons: a spectroscope by Hilger is ready for attachment.

THE LEIDEN OBSERVATORY.—We have received Prof. Bakhuyzen's Report on the work of the Observatory during the year ending Sept. 15, 1885. In March last preliminary work in connection with the installation of the new equatoreal was commenced. The object-glass of this instrument (furnished by Alvan Clark and Sons) is of 10½ inches aperture and 12½ feet focal length. The mounting was supplied by the Repsolds, and was finished by the beginning of August, and the instrument got ready for use. As far as it has yet been tested, Prof. Bakhuyzen expresses himself as well pleased with its performance, which compares favourably with that of other large instruments. The Leiden Observatory is therefore for the first time in possession of a refractor of a size adequate to the requirements of a first-class observatory, and we doubt not but that, in Prof. Bakhuyzen's hands, it will be made excellent use of.

During the year to which the Report refers the meridian circle was employed on observations of a restricted list of fairly bright stars situated in the immediate neighbourhood of the pole. It is expected that this list will be cleared off during the present winter. In the past year 340 observations of R.A. and 517 of declination of these stars were made. For time determinations 491 transits of clock-stars and 128 transits of Polaris for azimuth error were obtained. With the 7-inch refractor nine observations of Wolf's Comet were made. Between October 1884 and March 1885 investigations were carried out with reference to the errors of the observations of diameters of Mars and Uranus made with Airy's double-image micrometer in former years. These consisted in the measurement, with the double-image micrometer attached to the 7-inch equatoreal, of artificial disks formed by piercing circular holes in a copper plate, constructed and illuminated so as to resemble exactly the size and brightness of the planets themselves. The results of these investigations will be published shortly. During the month of September some observations were obtained, both of the brightness and distance from neighbouring stars, of the Nova in Andromeda. With the small equatoreal verifications of positions, in which errors were suspected, of some stars in the catalogue which is being prepared by Dr. Kam were made. Prof. Kapteyn has arranged to carry out a plan he has formed of undertaking the determination of stellar parallaxes by means of differences of R.A. observed with the meridian circle. The instrument is to be put at his disposal for some hours daily to enable him to carry out this important work. The reduction of the meridian observations 1877–1885 is in a forward state. Some progress has also been made in reducing the zone observations 1874–76. Dr. E. F. Bakhuyzen and Heer Wilterdink have been employed in these reductions. Prof. Bakhuyzen himself has been occupied with his work on the rotation period of Mars ('Observatory,' No. 104, p. 437), recently published as an extract from and in advance of vol. vii. of the 'Annals of the Leiden Observatory.' We hope that this volume will be soon published in its entirety, and thus the valuable results of meridian observations which have been accumulated during recent years be made available to astronomers generally.

THE DOUBLE STAR 61 CYGNI[*].—Dr. C. F. W. Peters, of Kiel, has succeeded in obtaining elliptic elements of the orbit of this celebrated double star, which appear to represent the observations from the earliest times down to 1883 with considerable accuracy. The last attempt at a determination of the orbit of this binary was, we believe, that made by Mr. N. M. Mann, of Rochester, N. Y. ('Sidereal Messenger,' March 1883), who obtained an ellipse with period 1159 years and eccentricity 0·2484. The places computed from this orbit agree with the observed places as closely as could perhaps be expected. It is of course impossible as yet to obtain any thing like a definitive orbit in the case of a body revolving in such an immense period as the companion star in this instance undoubtedly does; it is, however, a great step in advance to find that the long series of measures can be satisfactorily represented by an elliptic orbit. Dr. Peters finds the period of revolution to be 782·6 years, and the angle of eccentricity of the ellipse = 10° (e=0·1736), and gives the following ephemeris:—

Epoch	1885·0	1887·0	1889·0	1891·0	1893·0
Position ..	119°·7	120°·5	121°·3	122°·1	122°·8
Distance ..	20″·60	20″·81	21″·02	21″·23	21″·44

Taking the parallax of 61 Cygni to be 0″·37, Dr. Peters' elements give for the sum of masses of the components 0·826 that of the Sun, if the parallax be 0″·54 the fraction is 0·266; in the mean therefore the combined mass of the system is about one-half the Sun's mass, whilst the mean distance between the stars is about 70 times that of the Earth from the Sun.

[*] Astron. Nachr. Nos. 2708, 2709.

THE ORBIT OF IAPETUS *.—The outer satellite of Saturn ha been observed regularly at Washington since the erection of th 26-inch refractor. This paper contains a very thorough discussio by Prof. Hall of all the observations made by him between Jun 10, 1875, and February 29, 1884, as well as of a few made b Prof. Newcomb in 1874. During the years 1875, 1876, an 1877 Prof. Hall observed differences of R.A. and declination o Saturn and Iapetus, as well as the usual observations of position angles and distances. He expresses himself as well pleased with th results of this method of observing, and states that he consider that it is a better one for this satellite than that by position-angl and distance. Iapetus is so distant from it primary, that, notwithstanding the distance of Saturn from the Sun, the mass of the latter exerts an important influence on the motion of the satellite. Accordingly in deducing his finally adopted elements, Prof. Hall takes account of the periodical perturbations produced by the Sun. In computing these perturbations, the terms depending on the position of the satellite in its orbit were omitted; it was found, however, that the larger ones arising from this cause would change the apparent position of the satellite by as much as 0″·5, and ought strictly, therefore, to have been included. The action of Jupiter on Iapetus, as well as the long inequality between Iapetus and Titan (arising from the fact that five periods of Titan are nearly equal to one of Iapetus) have also been investigated by Prof. Hall, who concludes that these disturbing causes may, for the present, be left out of consideration. The following are the two sets of mean elliptic elements found by Prof. Hall from two series of observation, viz.:—(1) differences of R.A. and declination observed in 1875, 1876, and 1877; and (2) position-angles and distances observed from 1875 to 1884, both sets being corrected for the periodical perturbations produced by the Sun.

Epoch in G.M.T.	1876 Sept. 20·5.	
Mean Longitude at Epoch	7° 34′ 46″·1	Mean Eq. 1876·0.
Perisaturnium	350 22 25 ·4	
Node on Ecliptic	142 27 17 ·2	
Inclination to Ecliptic	18 33 4 ·3	
Mean Distance	515″·523 ± 0·0320	
Eccentricity	0·028087	

Epoch in G.M.T.	1880 March 17·0.	
Mean Longitude at Epoch	26° 46′ 26″·3	Mean Eq. 1880·0
Perisaturnium	353 14 56 ·5 + 86″·28 *t*	
Node on Ecliptic	142 26 41 ·4 − 126 ·00 *t*	
Inclination to Ecliptic	18 33 39 ·5 − 10 ·80 *t*	
Mean Distance	515·512 ± 0·0470	
Eccentricity	0·026950.	

The annual variations of the elements given above (deduced from a comparison of ancient and modern observations) include the effect of precession, t being the number of years from 1880·0. The periodic time, found by comparing Herschel's observations of 1789 with the conjunctions observed in 1880 and 1881, is 79·3310152 mean solar days. Combining this period with the final value of the mean distance 515″·5195, the reciprocal of the mass of Saturn is 3481·3 ± 0·54 [*]. This of course is the mass of the entire system of Saturn (including the planet, its ring, and satellites); but the mass of the ring needs a new determination before it can be used with certainty, as Bessel's value 1/118 is probably much too great, and nothing is known of the masses of the satellites except that of Titan, so that we are unable as yet to determine the mass of the planet apart from that of its system. Prof. Hall's valuable paper concludes with tables of the motion of Iapetus extending from 1875 to 1950.

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* Washington Observations for 1882. Appendix I.

THE TEMPERATURE OF THE SURFACE OF THE MOON.—An important memoir by Prof. Langley on the above subject, communicated to the National Academy of Sciences, October 17, 1884, was published a little while ago. Prof. Langley commences his memoir with a review of previous researches and especially of Lord Rosse's on the same subject. He next proceeds to investigate the diathermancy of glass for solar and lunar rays respectively, finding, as Lord Rosse had also done, that the solar rays passed through glass in a much larger proportion than the lunar rays did. But Prof. Langley did not consider that Lord Rosse's inference, that much of the Sun's heat was absorbed by the surface of the Moon, and so changed into heat of low refrangibility, was necessarily correct, since the Moon might exercise a *selective* absorption; and his observations have convinced him that this is the case to a remarkable extent, so that there is "a preponderance in the lunar spectrum of the rays of long wave-length and hence a tendency to cause a smaller percentage of lunar rays to be transmitted by glass than of solar, and this independently of any effect from heat re-radiated by the lunar soil."

Further observations recorded either in the paper before us, or in a later one laid before the Academy in November last, have led to the striking conclusion that we receive from the Moon heat of lower refrangibility than from the Sun, for whilst the solar spectrum terminates abruptly near the point where $\lambda = 3\mu$, the lunar is traceable much further. This result has an important bearing on another subject, the transmission of radiations of low wave-length through our atmosphere, for prior to Prof. Langley's researches it had been assumed that it was more opaque to the infra red than to the visible rays. The lunar heat spectrum which after much trouble Prof. Langley has been able to obtain shows two maxima—one corresponding to the maximum in the solar spectrum, and due to reflected light; the other indefinitely lower down, due to the Moon itself and corresponding, Prof. Langley considers from his study of the spectra of frigid masses, to a temperature below that of melting ice. A comparison of the spectra obtained from the Moon in summer with those obtained in winter shows that a much greater amount of heat is received from the Moon in winter than in summer. "This may simply be due to the greater amount of aqueous vapour in our own atmosphere in the summer as contrasted with the winter clarity."

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[*] Differing little from the value recently found by Dr. Meyer, viz. 3482·9.

In the paper read before the National Academy last November *, Prof. Langley also mentions that "by directing the bolometer to the zenith and to the horizon, the temperature of space has been measured by direct experiment for the first time." In these last experiments Prof. Langley has found that the atmosphere transmits the Earth's heat more readily than the Sun's.

CHANGES IN THE RADIATION OF HEAT FROM THE MOON DURING A LUNAR ECLIPSE.—The Earl of Rosse communicated to the Royal Dublin Society, on the 20th of April last, a paper by Dr. Boeddicker, "On the Changes in the Radiation of Heat from the Moon during the Total Eclipse of 1884, Oct. 4, as measured at the Observatory, Birr Castle." The subject of lunar heat has often been a matter of investigation at Birr Castle, but up to October 1884 no eclipse had been sufficiently favoured by the weather to admit of any decisive results. On this occasion, however, the sky suddenly cleared about half an hour before the total phase, and remained exceptionally clear throughout the night. The principal result of the observations was to show that the decrease of heat before the total phase took place much more rapidly than the increase after it, and that the minimum of the heat-effect fell decidedly later than the minimum of illumination, which might be supposed to coincide with the middle of the eclipse. The observed temperature fell to about $\frac{1}{90}$ of the full Moon value during the total phase, and had risen again to about its normal amount in about three hours after the middle of the eclipse.

Prof. Langley was able to confirm these results to a very considerable extent by bolometer observations made during the partial eclipse of 1885, Sept. 23. He states that "the deflection obtained from a portion of the lunar surface just in advance of the umbra did not very materially differ from that given by a similar portion over which the umbra had just passed." "The salient feature of these observations is the extraordinary rapidity with which the lunar surface parts with its heat, most of that which is radiated disappearing all but simultaneously with that reflected" †.

MINOR PLANET No. 250 has been named Bettina by Baron Albert de Rothschild.

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* 'Science,' Vol. vi. No. 146.

† Ibid. Vol. vii. No. 152.

Elements and Ephemeris for Comet Brooks 2 *.

By Drs. H. Oppenheim and Kreutz.

The following new elements have been computed by Dr. H. Oppenheim:—

T=1885 Nov. 25·49680 Berlin M.T.

$$\left.\begin{array}{lrrr} \omega \ldots\ldots\ldots\ldots & 35^\circ & 33' & 42''\!\cdot\!6 \\ \Omega \ldots\ldots\ldots\ldots & 262 & 10 & 17\cdot\!4 \\ i \ldots\ldots\ldots\ldots & 42 & 26 & 28\cdot\!8 \end{array}\right\} \text{Mean Eq. 1886·0.}$$

Log q=0·032946.

From these elements Dr. Kreutz has computed the following ephemeris for Berlin midnight:—

1886.	App. R.A. h	m	s	App. Dec. °	′	Log *r*.	Log Δ.
Mar. 3....	23	49	46	+27	21·8	0·2714	0·4109
7....	0	1	33	28	12·5	0·2820	0·4214
11...	0	13	3	28	59·9	0·2924	0·4317
15....	0	24	15	29	44·4	0·3027	0·4419
19....	0	35	10	30	26·2	0·3127	0·4518
23....	0	45	48	31	5·4	0·3224	0·4615
27....	0	56	11	31	42·1	0·3320	0·4710
31....	1	6	19	32	16·7	0·3414	0·4802

The brightness on March 3 is 0·2, and on March 31 is 0·1 of that at the time of discovery.

Elements and Ephemeris for Comet Fabry †. By Dr. H. Oppenheim.

The following elements and ephemeris have been computed from observations made at Munich, Lyons, and Vienna, Dec. 2, Berlin, Dec. 26, Padua, Jan. 1 and 3, Dresden, Jan. 22 and 31.

T=1886 April 5·5398 Berlin M.T.

$$\left.\begin{array}{lrrr} \omega \ldots\ldots\ldots\ldots & 126^\circ & 50' & 27''\!\cdot\!6 \\ \Omega \ldots\ldots\ldots\ldots & 36 & 19 & 54\cdot\!0 \\ i \ldots\ldots\ldots\ldots & 82 & 11 & 15\cdot\!0 \end{array}\right\} \text{Mean Eq. 1886·0.}$$

Log q=9·804021.

Ephemeris for Berlin Midnight.

1886.	App. R.A. h	m	s	App. Dec. °	′	Log *r*.	Log Δ.
Mar. 3....	23	20	9	+30	11·7	9·9707	0·1787
7....	23	19	34	31	19·6	9·9441	0·1621
11....	23	18	54	32	29·8	9·9171	0·1424
15....	23	18	11	33	42·0	9·8904	0·1191
19....	23	17	29	34	54·6	9·8650	0·0916
23....	23	16	58	36	5·6	9·8421	0·0589
27....	23	16	57	37	12·4	9·8233	0·0203
31....	23	17	59	38	11·5	9·8102	9·9744
Apr. 4....	23	20	55	38	58·9	9·8043	9·9198

The brightness on 1885 Dec. being taken as unity, that on April 21=83.

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* Astron. Nachr Nos. 2710, 2711.

† Ibid. No. 2711.

*Ephemeris for Comet Barnard**.

By Dr. A. Krueger.

(From the elements published in 'The Observatory,' No. 10 p. 112.)

For Berlin Midnight.

1886.	App. R.A. h m s	App. Dec. ° ′	Log *r*.	Log Δ.	Bright ness.
Mar. 2..	1 56 8	+21 28·4	0·1443	0·2429	3·7
6..	1 54 54	22 35·8	0·1229	0·2415	4·1
10..	1 53 55	23 45·9	0·1001	0·2390	4·6
14..	1 53 6	24 58·9	0·0757	0·2352	5·3
18..	1 52 26	26 14·9	0·0497	0·2299	6·1
22..	1 51 49	27 34·3	0·0217	0·2230	7·1
26..	1 51 13	28 57·0	9·9917	0·2144	8·5
30..	1 50 34	30 23·2	9·9594	0·2036	10·4

The brightness on 1885 Dec. 5 is taken as unity.

Dr. H. Oppenheim points out (Astron. Nachr. No. 2707) that allowing for some uncertainty in the computed brightness, we ought in the beginning of May, to see the unusual spectacle of two brigh comets (Fabry and Barnard) near each other, and at their culmi nation very near the zenith of stations in these latitudes.

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* Astron. Nachr. No. 2710.

THE "COMPANION" TO THE OBSERVATORY.

Numerous friends having written in the most flattering terms to express their satisfaction with the "Companion," the Editors desire to take this opportunity of thanking them, and of expressing their gratification that the publication should have met with such general approval. They would at the same time urge intended purchasers to make an early application for it, as but a limited number have been printed. The titlepage and index to Volume VIII. are published with the "Companion."

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Meeting of the Royal Astronomical Society on March 12, 1886 145
Articles:—
On the General Values of the Obliquity of the Ecliptic, and of the Precession and Inclination of the Equator to the Invariable Plane, taking into account Terms of the Second Order. By Prof. J. C. Adams, M.A., F.R.S. 150
The Geminids of 1885. By W. F. Denning, F.R.A.S. 154
The Nova and Nucleus of the great Andromeda Nebula. By the Rev. T. E. Espin, B.A., F.R.A.S. 156
Elements of Comet Barnard, 1886. By J. Morrison, Ph.D., F.R.A.S. 157
Maxima and Minima of Variable Stars observed during 1885. By Joseph Baxendell, Jun. 158
Maxima and Minima of Variable Stars observed during the Year 1885. By Joseph Baxendell, F.R.S., F.R.A.S. 159
Correspondence:—
Mira Ceti. By W. H. Numsen 160
Proposed Change in the Astronomical Day. By Prof. Asaph Hall, For. Assoc. R.A.S. 161
Transits of Jupiter's IVth Satellite. By Edmund J. Spitta, F.R.A.S. 161
The Discovery of the Star-cluster 22 Messier in Sagittarius. By W. T. Lynn, B.A., F.R.A.S. 163
Nebula observed by Hevelius in Hercules. By W. T. Lynn, B.A., F.R.A.S. 164
The Red Spot on Jupiter and its Junction with a Dark Southern Belt. By W. F. Denning, F.R.A.S. 165
Notes:—
The Binary Star β Delphini.—Dark Transits of Jupiter's Fourth Satellite.—An Observation of Neptune occurring in Lamont's Zones.—Elementary Star Atlas.—The Star-Guide.—Potsdam Observatory.—Stellar Photography.—Motion of the Solar System in Space.—The New Star in the Nebula in Andromeda.—Harvard College Observatory.—American Determinations of the Velocity of Light.—Universal Time.—The Change in the Astronomical Date.—Obituary: C. G. Talmage, F.R.A.S., and Mr. T. Bassnett 166–175
Ephemeris for Comet Fabry. By Dr. H. Oppenheim 176
Ephemeris for Comet Barnard. By Dr. H. Oppenheim 176

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Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"—
Astronomique (organ of the Paris Observatory).

CONTENTS OF No. 108.

Anniversary Meeting of the Royal Astronomical Society on February 12......
Meeting of the Liverpool Astronomical Society ....

Articles:—

Hill on the Lunar Inequalities due to the Ellipticity of the Earth. By Pr
J. C. Adams, M.A., F.R.S. ....
Maxima and Minima of Variable Stars. By George Knott, F.R.A.S.........
On the Variable Star T Aquilæ. By Joseph Baxendell, F.R.S., F.R.A.S.
The Variable Star S Vulpeculæ. By Joseph Baxendell, Jun. ....
History of Astronomy in the Nineteenth Century. By E. W. Maunder, F.R.A.

Correspondence:—

A probable Ancient View of the Solar Corona without an Eclipse. By W
T. Lynn, B.A., F.R.A.S. ....
Proposed Change in the Astronomical Day. By J. L. E. Dreyer, F.R.A.S
Trained Meteors. By W. H. S. Monck, M.A...
The Wedge Photometer. By Henry Parkhurst.......................................
The Comet of 1812 (Pons-Brooks) in 1884. By T. W. Backhouse, F.R.A.S
The Council of the Royal Astronomical Society. By the Rev. Prof. C. Prit
chard, F.R.S...

Notes:—

Austrian Observatories.—A New Observatory in Hungary.—Stability o
Saturn's Rings.—Halley's Southern Catalogue.—The Washington Ob
servatory.—The Leiden Observatory.—The Double Star 61 Cygni.-
The Orbit of Iapetus.—The Temperature of the Surface of the Moon.-
Changes in the Radiation of Heat from the Moon during a Luna
Eclipse.—Minor Planet No. 250 13

Elements and Ephemeris for Comet Brooks 2. By Drs. H. Oppenheim an
Kreutz ....
Elements and Ephemeris for Comet Fabry. By Dr. H. Oppenheim..............
Ephemeris for Comet Barnard. By Dr. A. Krueger ....
The "Companion" to The Observatory ....

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 109. APRIL. 1886.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, March 12, 1886.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel, and
Lieut.-Col. G. L. Tupman.

The Minutes of the previous ordinary Meeting were read and confirmed.

Col. Tupman announced that 122 presents had been received since the last ordinary Meeting, amongst them being 'Saunier's Horology,' presented by the translator, Mr. Tripplin.

A vote of thanks was passed to the respective donors.

Col. Tupman read a paper by Mr. Backhouse on the Great Shower of Andromedes on Nov. 27, 1885. Tables were appended, giving the number of meteors counted during the display, the time in seconds, the proportions of clear sky, and other particulars. The maximum observed was between $6^h\ 2^m$ and $6^h\ 12^m$. In Mr. Backhouse's opinion the shower was a little richer than that of 1866, and much richer than that of 1872. Of the meteors whose magnitudes were specially noted, 3 per cent. appeared as bright as Jupiter, 11 per cent. were of the first magnitude, 9 per cent. of the second, 20 per cent. of the third, 34 per cent. of the fourth, and 23 per cent. of the fifth magnitude. The brighter meteors left trains, most of a deep red colour; but the faint meteors had no perceptible trains. As a rule, the brighter the meteor the longer the path and duration. Mr. Backhouse had not calculated the position of the radiant-point, but considered that it must cover an area of several degrees in diameter situated near χ Andromedæ. Dr. Ballot, observing the meteors in the Transvaal, placed the radiant in the constellation Triangulum, more than 10° distant from χ Andromedæ. Perhaps this difference might have been due to the paths of the meteors being deflected downwards by the Earth's attraction. A good many meteors were observed on Nov. 28, 29, and 30, showing diminishing proportion of Andromedes; but no Andromedes we seen on Dec. 1.

Mr. Ranyard pointed out that ordinarily the velocity of meteo was so great that but a short time was spent in the neighbourho of the Earth, and consequently the Earth's attraction could on affect their paths to a very small extent. But in the present ca as the meteors overtook the Earth, the relative velocity was b comparatively small, only 11 miles a second, so that if the attra tion of the Earth could produce a shift in the radiant, this was very favourable opportunity for detecting it. Whether, howeve it could account for the great shift of the radiant referred to Mr. Backhouse he did not know. Much more evidence would required before this theory could be accepted as explaining t cause of so great a shift.

Col. Tupman. I do not think Mr. Backhouse puts it as strong as that: he only suggests that the Earth's gravity *might* be t cause of the shift.

Mr. Maunder read a paper on "Some recently published Spe troscopic Observations." He said:—There have been recent published three series of spectroscopic observations of so striki and novel a character that they ought not take their place accepted facts without thorough examination. It might see ungracious to challenge definite observations, but he had no id of calling in question the good faith of the observers, and dre attention to them only with the view of inducing other observe to follow up these observations, and give us results which mig confirm or discredit those before us.

The first series was the detection by Mr. Sherman, of Yale Co lege, of bright lines in stellar spectra. Mr. Sherman had not onl detected bright lines in the spectrum of Nova Andromedæ, an many more lines than any previous observer had seen in th spectra of β Lyræ and γ Cassiopeiæ, but he stated that he ha examined 50 other stars, and in *each* case had seen bright line either few or many. If this could be substantiated, it was a not worthy advance in stellar spectroscopy; but when the instrument means he used was examined, there were indications of a fault procedure. The spectroscope was not adjusted to the focus of th equatoreal for the extreme rays of the spectrum. Mr. Sherma described the bright lines as being stellar points in the centre o the spectrum, but as stretched out into bright lines at either end— a description which could hardly be that of true stellar bright line but which might apply to bright lines caused by some instrument defect, especially when combined with the faulty adjustment jus referred to. Mr. Sherman used an unusually wide slit—abou 100 times too wide—which would differ little from no slit at al Confidence could not be placed in measures with so wide a slit But the most suspicious part of the observations was that Mr Sherman never failed to see bright lines in any star which h examined; and though he described them as sometimes shining with metallic brilliancy, no other observer had ever detected them. His (Mr. Maunder's) experience was that if dark lines or bands were badly seen, an appearance of bright lines might result, because whilst the real dark lines escaped recognition as such, they yet produced their effect by causing the clear spaces between them to appear as bright lines from contrast. Prof. Vogel had recently published a criticism of Mr. Sherman's observations, in which he mentioned how Secchi at one time thought he had discovered a system of bands in the spectrum of Sirius, but afterwards found it due to the loosening of the prisms of his train.

The second series of observations were those made by Dr. Copeland of Nova Orionis. Here the observations themselves could not be called in question; the only point was the interpretation to be put upon them. In this spectrum the contrast of light and darkness was unusually pronounced, and it became a question whether the spectrum should be regarded as a brilliant continuous one crossed by dark lines, or as a feeble continuous spectrum with vivid bright bands superposed upon it. Hitherto most observers had taken the former view. Dr. Copeland, however, favoured the latter, and he further identified some of the bright bands as being those characteristic of hydro-carbon and cometary spectra. Of the importance of that view, if substantiated, there could be no doubt; but it seemed very questionable whether Dr. Copeland had made out his case for a coincidence between the bright spaces and the hydro-carbon bands. Of the three cometary bands there was only one which could be supposed to correspond to any of the bright spaces in the spectrum of the star. An additional reason for thinking that the dark bands were true absorption-bands and not the effects of contrast was that, in bright stars of the type, if a great dispersion was used the bands were sometimes actually seen to break up into individual lines, and all appearance of bright lines was lost.

The third series of observations were those which had been recently published in the 'Bulletin Astronomique' by M. Trouvelot, and dealt with the displacements he had observed in the spectra of solar prominences. The one to which special attention was invited was the one M. Trouvelot had numbered as the fifth, and was made on June 26, 1874. He saw a great prominence over 200 seconds in height, and at first had the slit opened so wide as to see it all at once. He then nearly closed the slit, and he still saw the prominence absolutely unchanged—at least he so represented it in the diagrams accompanying the paper, and he also spoke about it in very definite language. Whilst he was observing it a little later with slit wide open, it instantaneously disappeared "like a flash of lightning." M. Trouvelot's conclusion was that this prominence was receding from him at the tremendous speed of 2584 km. per second, and had suddenly gone round the Sun's limb and so disappeared. But if his diagram was looked at attentively, that was seen not to be exactly the true inference to draw. If the observation was to be accepted as it stood, it meant not that the prominence was moving at the speed of 2584 km. per second, but that it was moving at every and all conceivable speeds from rest up to that inconceivable velocity. It was sufficient merely to state the observation to show that there was some mistake somewhere; or if not, the view hitherto held that the displacement of the spectroscopic lines was the true index of the velocity of motion in the line of sight must be given up.

The President. I am sure the meeting will agree with me that there was no need for Mr. Maunder's disclaimer with regard to the nature of his criticism. No critic ever brought forward his criticisms in a manner which could be less objectionable to the persons criticised.

Mr. Ranyard. No one ever, I am sure, saw a prominence with the slit more than three minutes in width. My only suggestion is that M. Trouvelot had his slit radial, and there was a displacement of the lines which he mistook for a prominence, and that he did not know the position of the slit.

Mr. Maunder. M. Trouvelot is very definite in his description. The diagram shows the prominence with the slit wide open and with it nearly closed.

Mr. Ranyard. He could not have seen the form of the prominence with the slit open to a width of 3 minutes of arc.

Mr. Maunder. If his diagram is to be taken as true to scale, the slit was open three minutes in the first place, and was reduced to about five seconds in the second observation.

Mr. Horner. I do not think that it is so very extraordinary to see a prominence with the full slit open. I have often seen one so myself. I use a converted Browning star-spectroscope, with two very powerful prisms by Hilger. I do not know how wide its slit will be.

Col. Tupman. About one twentieth of an inch. The width in seconds depends upon the focal length of the object-glass of the telescope.

Mr. Horner. I have seen prominences with that width of slit on many occasions; some care is required in shading the eye. I use a telescope with an aperture of 5 inches, and a focal length of 6 feet. With regard to the point of the bright lines in stellar spectra, I should be glad if any Fellow will tell me how often he has seen bright lines in γ Cassiopeiæ, because I have often observed the star and have never been able to see them with that aperture, though I have made all sorts of different arrangements. I have seen Secchi's black lines very often. You can bring up most perfect black lines by means of a shifting of the prisms. With regard to the bright lines in Nova Andromedæ, I could not make an attempt to see them with so small an aperture, but I thoroughly endorse what Mr. Maunder says about fictitious bright lines. I think it is the easiest thing in the world to be led into mistake by the contrast between the dark lines and the clear spaces where there are no dark lines, and to imagine the latter to be true bright lines.

The President. May I ask have you seen anything to confirm Mr. Sherman's observations?

Mr. Horner. Nothing whatever; quite the reverse.

Mr. Maunder. My surprise was not that M. Trouvelot saw his prominence with the slit open, but that he saw it with the slit shut. (Laughter). The slit he used was a tangential slit and not a radial slit.

The President. If no other Fellow desires to make any further remarks, I am sure we will give Mr. Maunder a vote of thanks, and I hope his paper may cause Mr. Sherman to explain more fully his method of observation.

Mr. Knobel read a paper by *Professor Pritchard* on the new star in Orion photometrically and spectroscopically observed at the Oxford University Observatory between Dec. 22 and Jan. 10. A diminution of magnitude was observed from 6·46 to 7·09; the colour of the star on Dec. 23 was a reddish orange. As to the character of the spectrum, it was seen at Oxford to be crossed by 6 dark bands. The apparently contradictory results obtained at different observatories were very perplexing.

Mr. Maunder. I would only refer to the last sentence in Prof. Pritchard's paper. I do not think there is any real contradiction in the actual observations made at Dunecht and at Greenwich as to the spectrum of Nova Orionis, but simply as to the interpretation to be placed upon them. All observers have seen a spectrum in which dark and bright spaces follow each other alternately, and all are practically agreed as to the positions of the limits of those bright and dark spaces. The only question is as to whether we are to regard the bright spaces as being the feature of the spectrum, and as really showing the existence of bright bands, or whether we are to regard the dark spaces as being the feature of the spectra, and as being true absorption bands. I think that this star may lead us to the conclusion that those stars of the third type which are variable, vary in the brilliancy of the continuous spectrum and not, as has been supposed, in the intensity of the absorption bands. I think it is clear, in this particular instance, that it is an increase in the brilliancy of the continuous spectrum which has given rise to the sudden appearance of this star.

A vote of thanks was passed to Prof. Pritchard for his paper.

Mr. Chambers stated that he was preparing a catalogue of red stars for general use, and that he should be very glad to receive notes of any uncatalogued red stars which might have been picked up by Fellows of the Society.

The following papers were also announced:—

Communicated by the *Astronomer Royal.* "Observations of Comet *d* 1885 (Fabry) and *e* 1885 (Barnard) made at the Royal Observatory, Greenwich."

J. G. Lohse. "Observations of the new Star in Andromeda, made at Mr. Wigglesworth's Observatory, with the 15·5-in Cooke Refractor."

J. Tatlock. "Occultations observed at Beloit, Wisconsi U.S.A."

J. E. Gore. "On the Orbit of 40 (o^2) Eridani."

Rev. T. E. Espin. "Some new Red and Orange-red Stars."

J. Tebbutt. "Observation of the Conjunction of Saturn a μ Geminorum."

E. B. Powell. "Additional Remarks on the Periodic Time α Centauri."

Rev. S. J. Perry. "Occultations of Stars by the Moon an Phenomena of Jupiter's Satellites observed at Stonyhurst in t Year 1885."

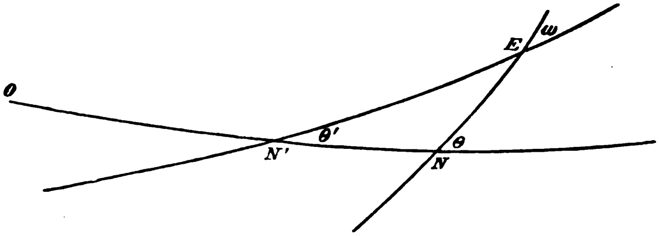
The Meeting adjourned at 9.20 P.M.

On the General Values of the Obliquity of the Ecliptic, and the Precession and Inclination of the Equator to th Invariable Plane, taking into account Terms of the Secon Order.*

If we adopt the values of the precession and nutation employed b Peters in his classical work 'Numerus Constans Nutationis,' I fin that the ratio of the sum of the masses of the Earth and Moon t the mass of the Moon is that of 82·834 to 1, a result which diffe slightly from that found by Peters from the same data.

The amount of precession caused by the Sun's action depends i a slight degree on the eccentricity of the Earth's orbit. In ord to find the precession for an indefinite period, it will be proper t employ the *mean* value of the square of this eccentricity instead o the value of this quantity at the present time.

Taking this circumstance into account, and also introducing th small correction of the coefficient of precession which depends o the square of the coefficient of nutation, I find that if ω be th



obliquity of the ecliptic at any time, the rate of the luni-sola precession at that time during a Julian year will be represente by $c \cos \omega$, where $c = 54''\cdot94625$ nearly.

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* Abstract of a paper read 1884 Sept. 11, at the Philadelphia meeting of th American Association for the Advancement of Science.

Now let ON′N be the fixed plane of reference, which may be either the ecliptic at a given epoch, or, better still, the invariable plane of the system, or any other arbitrary fixed plane.

$$\left.\begin{array}{l}\text{N}'\text{E the position of the ecliptic}\\ \text{and NE that of the equator}\end{array}\right\}\text{ at any time } t.$$

So that the point E is the autumnal equinox at that time, $ON=\phi$, $ON'=\phi'$, O being a fixed point, θ and θ' the inclination of the equator and ecliptic respectively to the fixed plane, and ω the angle N′EN, or the obliquity of the ecliptic at time t. Also let $NE=\lambda$. Then the quantities $p=\tan\theta'\sin\phi'$ and $q=\tan\theta'\cos\phi'$ are known in terms of t from the theory of the secular variations of the plane of the Earth's orbit, and θ' may be considered as a small quantity of the first order, the square of which we propose to take into account.

In the triangle N′EN we have

$$\begin{aligned}\cos\omega&=\cos\theta\cos\theta'+\sin\theta\sin\theta'\cos(\phi-\phi'),\\ \sin\omega\cos\lambda&=\sin\theta\cos\theta'-\cos\theta\sin\theta'\cos(\phi-\phi'),\\ \sin\omega\sin\lambda&=\sin\theta'\sin(\phi-\phi'),\end{aligned}$$

which give ω and λ when θ and ϕ are known.

From the instantaneous motion of the equator with reference to the ecliptic at time t, supposed for an instant to be fixed, it is easily seen that we have

$$\begin{aligned}\frac{d\phi}{dt}&=-c\frac{1}{\sin\theta}\cos\omega\sin\omega\cos\lambda,\\ \frac{d\theta}{dt}&=\quad c\cos\omega\sin\omega\sin\lambda,\end{aligned}$$

or, substituting from above for $\cos\omega$, $\sin\omega\cos\lambda$ and $\sin\omega\sin\lambda$,

$$\frac{d\phi}{dt}=-c\frac{\cos^2\theta'}{\sin\theta}\{\cos\theta+\sin\theta\tan\theta'\cos(\phi-\phi')\}\{\sin\theta-\cos\theta\tan\theta'\cos(\phi-\phi')\}$$

$$\frac{d\theta}{dt}=\quad c\cos^2\theta'\{\cos\theta+\sin\theta\tan\theta'\cos(\phi-\phi')\}\tan\theta'\sin(\phi-\phi'),$$

which are the differential equations for determining θ and ϕ, θ' and ϕ' being supposed to be already known in terms of t.

From the above we may deduce the following :—

$$\frac{d}{dt}\left(\frac{\cos\omega}{\cos\theta'}\right)=\frac{dq}{dt}(\sin\theta\cos\phi)+\frac{dp}{dt}(\sin\theta\sin\phi).$$

The integrations of these equations may be readily effected by the method of indeterminate coefficients.

Suppose the values of p and q to be

$$\begin{aligned}p&=\Sigma\gamma_i\sin(g_it+\beta_i),\\ q&=\Sigma\gamma_i\cos(g_it+\beta^i),\end{aligned}$$

where i takes the successive integral values 0, 1, 2, &c., equal in number to the number of planets considered, and the quantities γ_i, g_i, and β_i are known constants.

Then we may find that

$$\begin{aligned}\theta = h &+ \tfrac{1}{2}\tan h\,\Sigma a_i(a_i-1)\gamma_i^2 + \tfrac{1}{2}\cot h\,\Sigma(a_i-\tfrac{1}{2})\gamma_i^2\\ &+ \Sigma a_i\gamma_i\cos\{(k-g_i)t+\alpha-\beta_i\}\\ &+ \Sigma a_{ii}(\gamma_i)^2\cos 2\{(k-g_i)t+\alpha-\beta_i\}\\ &+ \Sigma a_{ij}\gamma_i\gamma_j\cos\{(2k-g_i-g_j)t+(2\alpha-\beta_i-\beta_j)\}\\ &+ \Sigma a'_{ij}\gamma_i\gamma_j\cos\{(g_i-g_j)t+\beta_i-\beta_i\}.\end{aligned}$$

And

$$\begin{aligned}\phi = kt &+ \alpha \times \Sigma b_i\gamma_i\sin\{(k-g_i)t+\alpha-\beta_i\}\\ &+ \Sigma b_{ii}(\gamma_i)^2\sin 2\{(k-g_i)t+\alpha-\beta_i\}\\ &+ \Sigma b_{ij}\gamma_i\gamma_j\sin\{(2k-g_i-g_j)t+(2\alpha-\beta_i-\beta_j)\}\\ &+ \Sigma b'_{ij}\gamma_i\gamma_j\sin\{(g_i-g_j)t+\beta_i-\beta_j\},\end{aligned}$$

in which i and j are supposed to be different integers.

Also

$$a_i = \frac{k}{k-g_i}, \text{ and therefore } a_i - 1 = \frac{g_i}{k-g_i};$$

$$a_{ii} = -\tfrac{1}{4}a_i(a_i^2-1)\tan h - \tfrac{1}{4}a_i^2\cot h;$$

$$a_{ij} = -\tfrac{1}{2}\frac{k}{2k-g_i-g_j}\{(a_i^2+a_j^2-2)\tan h + (a_i+a_j)\cot h\};$$

$$a'_{ij} = \tfrac{1}{2}\frac{k}{g_i-g_j}\{a_i^2-2a_i-a_j^2+2a_j\}\tan h + \tfrac{1}{2}\frac{k}{g_i-g_j}(a_i-a_j)\cot h.$$

Also

$$b_i = -a_i(a_i-1)\tan h - a_i\cot h;$$

$$b_{ii} = \tfrac{1}{8}a_i^2(a_i-1)^2\tan^2 h + \tfrac{1}{4}a_i(a_i^2+a_i-1) + \tfrac{1}{4}a_i^2\cot^2 h;$$

$$\begin{aligned}b_{ij} = &-\frac{k}{2k-g_i-g_j}a_{ij}\tan h - \tfrac{1}{2}\frac{k}{2k-g_i-g_j}\{a_i(a_i-1)+a_j(a_j-1)\}\tan^2 h\\ &+\tfrac{1}{2}\frac{k}{2k-g_i-g_j}\{a_i^2+a_i-1+a_j^2+a_j-1-a_ia_j\}\\ &+\frac{k}{2k-g_i-g_j}(a_i+a_j)\cot^2 h;\end{aligned}$$

$$\begin{aligned}b'_{ij} = &-\frac{k}{g_i-g_j}a'_{ij}\tan h + \tfrac{1}{2}\frac{k}{g_i-g_j}\{a_i(a_i-1)+a_j(a_j-1)\}\tan^2 h\\ &-\tfrac{1}{2}\frac{k}{g_i-g_j}\{a_i^2+a_j^2+a_ia_j-5a_i-5a_j+6\};\end{aligned}$$

or the value of this last coefficient may be otherwise expressed, thus—

$$b'_{ij} = -\tfrac{1}{2}\frac{k}{g_i-g_i}\{(a_i-1)(a_j-1)(a_i+a_j)\tan^2 h + (a_i+a_j-2)(a_i+a_j-3)\}.$$

Also the value of ω, the obliquity of the ecliptic, is thus expressed in terms of the same quantities :

$$
\begin{aligned}
\omega = h &+ \Sigma(a_i-1)\gamma_i \cos\{(k-g_i)t+\alpha-\beta_i\} \\
&+ \Sigma[-\tfrac{1}{4}a_i(a_i-1)^2 \tan h - \tfrac{1}{4}(a_i-1)^2 \cot h]\gamma_i^2 \cos 2\{(k-g_i)t+\alpha-\beta_i\} \\
&+ \Sigma\Big[-\tfrac{1}{2}\frac{k}{2k-g_i-g_j}(a_i^2+a_j^2-2)\tan h - \tfrac{1}{2}\frac{k}{2k-g_i-g_j}(a_i-a_j)\cot h \\
&\qquad + \tfrac{1}{2}(a_i^2+a_j^2-a_i-a_j)\tan h + \tfrac{1}{2}(a_i+a_j-1)\cot h\Big] \\
&\qquad\qquad \times \gamma_i\gamma_j \cos\{(2k-g_i-g_j)t+2\alpha-\beta_i-\beta_i\} \\
&+ \Sigma\Big[\tfrac{1}{2}\frac{k}{g_i-g_j}(a_i-a_i)(a_i+a_j-2)\tan h + \tfrac{1}{2}\frac{k}{g_i-g_j}(a_i-a_j)\cot h \\
&\qquad - \tfrac{1}{2}(a_i^2+a_j^2-a_i-a_j)\tan h - \tfrac{1}{2}(a_i+a_j-1)\cot h\Big] \\
&\qquad\qquad \times \gamma_i\gamma_j \cos\{(g_i-g_j)t+\beta_i-\beta_j\}.
\end{aligned}
$$

Also the value of k in terms of the constant c which, as stated before, is known from the theory of precession is

$$k = -c \cos h \,\{1-\Sigma\tfrac{1}{4}(a_i-1)\,(3a_i-5)\,\gamma_i^2\}\,;$$

h and α are the arbitrary constants which enter into the complete integrals of our equations, and they are determined so as to make the initial values of θ and ϕ, or those of ω and ϕ, equal to the observed values.

It is to be remarked that one of the values of g is 0, and if the invariable plane of the system be taken as the fixed plane of reference, the corresponding value of γ will be also zero, so that the expression for θ, ϕ, and ω will be considerably simplified by this choice of the fixed plane.

According to Stockwell's determination, in Vol. 18 of the Smithsonian Contributions, the longitude of the ascending node of the invariable plane on the ecliptic of 1850 is 106° 14′ 18″, and the inclination of this plane to the same ecliptic is 1° 35′ 20″.

Also, as already mentioned, if we make the invariable plane of the system our plane of reference, we have for $g_0=0$, $\gamma_0=0$; and the remaining values of g_i and those of log γ_i which correspond to to them, according to Stockwell's determination, will be the following :—

	$i=1$	$i=2$	$i=3$	$i=4$	$i=5$	$i=6$	$i=7$
g_i...	−2″·9161	−25″·9350	−5″·21365	−6″·6693	−17″·6266	−18″·9365	−0″·66166
β_i...	133° 57′	126° 20′	19° 7′	307° 17′	300° 1′	254° 43′	20° 31′
log γ_i...	7·20626	7·44481	8·01815	7·84525	7·59939	8·41184	7·12320

where the quantities g_i are expressed in seconds and have reference to a Julian year as the unit of time, and the quantities γ_i are expressed in circular measure.

Hence we may find, with reference to the invariable plane, for the epoch 1850:—

$$\theta = 23^\circ\ 3'\ 42''\cdot 7$$
$$\phi - \phi' = 257\ \ 20\ \ 21\ \cdot 5$$

Now in the figure before given the point N′ is the descending node of the invariable plane on the ecliptic of 1850, so that the longitude of N′ is 286° 14′ 11″·8.

Also the longitude of the point E, which is the autumnal equinox, is 180°. Hence N′E = 253° 45′ 54″.

Whence we may find for 1850:

$$\theta = 23^\circ\ 3'\ 42''\cdot 7$$
$$\phi - \phi' = 257\ \ 20\ \ 21\ \cdot 5$$
$$\text{or}\qquad \phi = 183\ \ 34\ \ 39\ \cdot 5$$

Also, according to Stockwell, the obliquity of the ecliptic in 1850 was

$$\omega = 23^\circ\ 27'\ 31''\cdot 0.$$

Hence by repeated approximation we may find.

$$h = 23^\circ\ 18'\ 54''\cdot 0 \text{ nearly}$$
$$a = 177\ \ 25\ \ 42 \quad ,,$$
$$\text{also}\qquad k = \quad -50\ \cdot 4614$$

whence by substitution all the terms in θ, ϕ, and ω may be found numerically.

J. C. Adams.

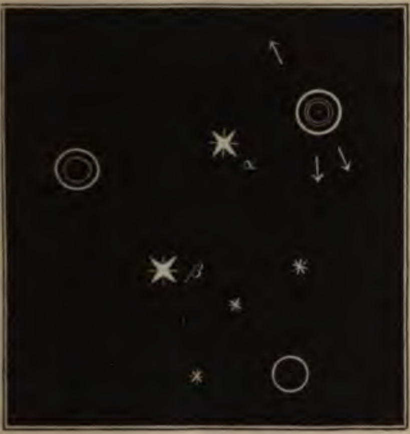
The Geminids of 1885.

On the nights of Nov. 30, Dec. 1, 4, 7, 8, 9, and 10, 1885, during watches amounting in the aggregate to 24¼ hours, I observed 252 meteors, of which about 66 were Geminids. On the first night of the series, Nov. 30, I saw no indication that the display had actively opened, though I looked persistently towards a region not far W. of its radiant-point during a period of 4½ hours in the early part of the night. On Dec. 1 I saw that meteors began to fall, somewhat scantily it is true, from near the normal position, and on Dec. 4 the shower had so far developed as to form the richest display visible.

Summarizing my results up to Dec. 10 (after which no prolonged observations could be obtained) it appears that the radiant is a triple one, sharply defined at the following points:—

I.	107°	+33°	34 meteors.
II.	117	+32	21 „
III.	110	+25	11 „

The first of these probably represents the true Geminids, while the two others are implicated in apparently diffusing the radiant as well as considerably augmenting the numerical strength of the display. The meteors from II. were brighter generally than those of either I. or III.



Triple radiant-point of Geminids, Dec. 1–10, 1885, relatively to α and β Geminorum, also three nearly stationary Geminids.

I.=Chief shower W. of α.

II.=Secondary shower E. of α.

III.=Minor shower S.W. of β.

It is not a little curious that these radiants form a contemporary series of showers well visible in the morning hours of October, when I have occasionally seen them in past years. In 1877 I. and II. were actively visible in that month, and during the present year, between October 6 and 12, I detected a very well-marked radiant of bright and swift streak-leaving meteors from 103° +33°. As to the shower III., that represents the same position as the Sept., Oct., and Nov. Gemellids, and I have seen it to the best advantage on the following nights:—

1877 September 15	113°	+24°
1879 September 25	108	+24
1879 October 15	106	+23
1876 October 29	109	+23
1877 November 7	110	+25
1876 November 19	111	+22
1885 December 4	110	+25

Mr. Corder saw some fine, long meteors from it on Dec. 9, 1877, and from a comparison of many fireball observations between Oct. 15 and 22 I derived a radiant at 106° +23°. Prof. Herschel has also given three radiants for fireballs obviously belonging to this special system, viz.:—

Fireball of	Radiant.	
1862 November 27	102°	+26°
1877 December 9	112	+27
1863 December 12	105	+27

I have found the meteors very swift, leaving long bright streaks, in the morning sky of September and October. In November the velocities have moderated, and in December, when accompanying the true Geminids, they can no longer be described as swift.

As to the relative strength of the Geminid shower this year, it cannot be sufficiently gauged owing to the lack of observations on Dec. 11 and 12, when probably the maximum was attained. With regard to the chief radiant at 107° +33°, it well agrees with Mr. Greg's mean of 14 positions at 105° +32° and with my own previous determinations of the shower. Prof. Herschel found the point at 105° +30° on Dec. 12–13, 1863, and at 108° +33° on Dec. 12, 1872; while Mr. Corder gives 107° +35° as his mean position for Dec. 10–13 from 206 conformable meteors. Lieut.-Col. Tupman's radiant at 110° +40° on Dec. 12, 1870, is much too far N., so also Greg's observed position at 104° +39° for Dec. 9–11, 1877.

It would be interesting to trace yet more closely these possibly associated showers of Geminids from their first oncoming in September until they culminate in the maximum during the first half of December.

W. F. Denning.

Bristol, 1886, March 2.

The Nova and Nucleus of the great Andromeda Nebula.

The following are my observations of the magnitude of the Nova in the Andromeda Nebula. The telescope used was a 17¼-inch equatoreal reflector.

1885. Sept. 27, 8·0±; Oct. 1, 8·5; Oct. 3, 8·5; Oct. 9, 8·8;
Nov. 5, 9·3; Nov. 14, 10·0; Nov. 30, 10·7; Dec. 11, 11·5.
1886. Jan. 5, 12·5; Feb. 4, 13·0; Mar. 6, 13·5.

The colour from Sept. 27th to December 11th was always yellowish white. I have never seen the Nova either orange, green, or blue, as other observers have seen it. On several nights the star was observed with powers of 500, and on one or two with 1000, but it was in no way different to any other star, and seemed quite separate and distinct from the nebulous background. The last observation, March 6th, was made when the nebula was far away from the meridian; but the night was extremely fine, and the star was glimpsed but with considerable difficulty. The *minimum visibile* of the 17¼-inch reflector, on a fine night and with a dark background, is 15·0. This has been found by observations in the zone following ε Orionis, being one of the four that Professor E. C. Pickering requested observations of.

Mr. Webb's star, *p* the nucleus and the Nova, has been rated 10·5 throughout the observations. No alteration has been observed in the nebula itself. The nucleus of the Nebula has been carefully observed, and it may not be without interest to transcribe the notes made at the telescope:—

Sept. 27. With 70 the nucleus looked like a star of the 11·0 mag., but with 300 I could not confirm this.

Oct. 1. Same observation.

Dec. 11. The nucleus at times sparkled as if there was a small star in it: power 300.

1886, Jan. 5. With 300 I strongly suspected the existence of a star in nucleus; it was not in the centre of the nucleus, but *p*. With 500 this was fully confirmed. I then tried 950 (single lens), but this was too high; returning to 300, I estimated the star as brighter than the Nova by about a magnitude.

Feb. 4. With 300 and 500 the nucleus decidedly stellar.

March 6. With 400 and 500, Mr. Webb's star was quite sharply defined, although the object was low. Nucleus bright; the star could not be clearly made out, but the nucleus sparkled as if two or three small stars were present. T. E. Espin.

Wolsingham, Darlington,
1886, March 8th.

Elements of Comet Barnard, 1886.

These elements are founded on the following observations, viz.:—

*Munich M.T.	R.A.	Dec.	Comp. Star.
d h m s	h m s	° ′ ″	
1885 Dec. 12 11 52 55...	4 0 14·77	+ 5 33 36·2	ν Tauri, Ber. Jahr.
1886 Jan. 21 7 6 27...	2 31 29·01	+11 59 59·1	31 Arietis, 9 yr. Cat.
Washington M.T.			
1886 Mar. 1 7 39 48·1	1 56 28·44	+21 11 40·9	$W_{(2)}$ 1^h; 1210.
" "	1 56 28·39	+21 11 40·7	$W_{(2)}$ 1^h; 1217.

* See Astr. Nach. No. 2709.

These observations were corrected for aberration and parallax by means of approximate parabolic elements previously computed from other observations embracing a shorter period.

The computation has been carried to the utmost degree of accuracy, the three values of $\log p$ (the semi-parameter) coming out thus—9·9818784, 9·9818782, and 9·9818784, and the three values of T agreeing to the sixth decimal place.

T = 1886 May 3·06939 Washington M.T.

ω	119° 34′ 50″·649	Mean Eq. 1886·0.
☊	68 18 43 ·486	
i	84 27 4 ·648	
e	1·00067106	
$\log a$	2·8539414	
$\log q$	9·6807028	

The middle place is exactly satisfied.

If the observations are correct—and I have no reason to doubt their accuracy—the orbit of this comet is decidedly hyperbolic. The position of the comet with regard to the Earth and the Sun is such that a small error in the observations exercises a great influence on the final results. In order to decide whether the orbit is an ellipse or hyperbola, observations embracing a long period will be required.

J. Morrison.

Maxima and Minima of Variable Stars observed during 1885.

My observations of Variable Stars during 1885, from which the following observed times &c. of maxima and minima have been obtained, were made with the equatoreally mounted 6-inch achromatic of this observatory, using constantly a power of 80.

Star.	Time of Minimum.	Mag.	Time of Maximum.	Mag.
S Boötis	Apr. 4	13·6	Aug. 15	9·4
	Dec. 31 ±	13·3		
U Cephei	Aug. 3, $11^h\ 51^m$	9·3		
R Urs. Maj.	Mar. 23	13·3	July 1 ±	7·3
	Dec. 29	13·2		
S Urs. Maj.	Jan. 16	12·2	May 7	7·2
	Aug. 28	12·8	Dec. 25	7·9
T Urs. Maj.	Mar. 18	13·25	July 2	8·2
	Nov. 28	13·1		
R Cephei	My observations of this star show that its light fluctuated only about two-tenths of a magnitude during the year.			

The Observatory, Birkdale,
Southport, 1886, Mar. 17.

Jos. Baxendell, Jun.

Maxima and Minima of Variable Stars observed during the Year 1885.

The observations from which the following results are derived were made with the same telescope and powers that were used in 1884.

Star.	Max. or Min.	Observed Time.	Mag.	Star.	Max. or Min.	Observed Time.	Mag.
ssiop. ...	M.	Oct. 16	7·8	S Vulpec.......	M.	Sept. 11	9·1
phei ...	*m.*	Mar. 9^{d} $9^{h} 43^{m}{\cdot}5$	9·4	„	*m.*	Oct. 30	9·75
...	*m.*	Aug. 3 11 53 ·5	9·3	„	M.	Nov. 20	8·9
ietis......	M.	Feb. 3	9·0	S Cygni	M.	Nov. 6	9·5
i	M.	Feb. 14	2·6	T Aquilæ......	*m.*	June 10	10·8
rsei	M.	Dec. 6	7·7	„	M.	Aug. 18	9·2
onis......	M.	Dec. 15	9·0	„	*m.*	Oct. 2	10·9
n. Min. .	*m.*	April 19	13·1	„	M.	Dec. 25	9·2
melop....	M.	Feb. 18	8·2	R Sagittæ ...	*m. s.*	Jan. 8	9·0
„ ...	M.	Nov. 14	7·8	„ ...	*m. p.*	April 27	9·7
tis	M.	May 13	7·8	„ ...	M. *p.*	May 8	8·65
oötis	*m.*	April 22	13·3	„ ...	*m. s.*	May 30	8·95
„	M.	June 23	9·5	„ ...	M. *s.*	June 21	8·75
rona ...	M.	May 8	7·6	„ ...	M. *p.*	Aug. 4	8·75
lerculis ...	M.	July 14	7·4	„ ...	*m. p.*	Sept. 17	9·9
rsæ Min.	*m.*	Sept. 27		„ ...	M. *p.*	Sept. 30	8·65
raconis ...	M.	Dec. 26		„ ...	*m. s.*	Oct. 20	8·9
erculis ...	M.	June 11	6·4	„ ...	*m. p.*	Nov. 24	9·9
lerculis ...	M.	April 28	7·9	U Cygni	M.	May 28	7·5
„ ...	*m.*	July 20	12·9	V Cygni	*m.*	May 31	13·2
„ ...	M.	Oct. 13	7·8	„	M.	Dec. 30	9·5
erpentis...	M.	Sept. 14	10·5	R Delphini ...	*m.*	June 25	11·1
ygni	M.	Feb. 20	8·2	„ ...	M.	Oct. 15	9·0
ulpec.......	*m.*	June 12	9·8	S Delphini ...	M.	Aug. 8	10·1
„	M.	July 1	9·2	R Cassiop. ...	M.	Feb. 6	6·1
„	*m.*	Aug. 20	9·7				

Notes.

R Arietis.—This is the lowest maximum magnitude I have yet observed.

R Persei.—This was an unusually high maximum.

R Ursæ Min. and *R Draconis.*—The magnitudes are not given, as those of the comparison stars have not been verified.

T Aquilæ.—This star is Schönfeld's S Aquilæ. For the results of a discussion of the observations of this variable, see 'Observatory,' No. 108, p. 122.

R Sagittæ.—The letters *p.* and *s.* in the second column signify principal and secondary. A principal minimum occurred about July 18, but the observations were not sufficiently numerous for the determination of the exact date. In August, when a secondary minimum was due, the magnitude remained constant at 8·8 for a period of 16 days.

V Cygni.—At minimum the magnitude of this variable remained unchanged for a period of four months. The magnitude at the October 1884 maximum (given in the 'Observatory,' No. 97, p. 171) is 8·5, but should have been 9·4.

R Delphini.—This is Schönfeld's S Delphini.

S Delphini.—This is Schönfeld's T Delphini. Its magnitude at the maximum in August was the lowest maximum magnitude I have yet observed.

Observations were made of twenty other variable stars, but their light-curves did not afford any trustworthy dates of maxima or minima.

In the 'Observatory,' No. 97, p. 171, "χ Cygni" is misprinted "X Cygni." JOSEPH BAXENDELL.

March 16, 1886.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Mira Ceti.

GENTLEMEN,—

About the middle of December last, in casually looking over some of my back numbers of 'Nature,' I noticed the statement that "a maximum of Mira was due about Dec. 19, according to Argelander's formula of sines, but that it might occur earlier." On December 11, the first clear night thereafter, I consulted Heis's Atlas, and, satisfying myself as to the exact position of Mira, commenced observations.

Argelander's "step" method was used in all the comparisons, and the magnitudes of the comparison stars are taken as given in the Harvard Photometry. On December 11 and 12 Mira was estimated as just about equal to H.P. 270, and more than five steps fainter than ρ or ε Ceti, and its adopted magnitude for those dates was put down at 5·5. Bright Moon and bad weather then interfered until December 26, when a marked increase in brightness had taken place. It was then estimated as 2 steps brighter than ν Ceti, and about 1–2 fainter than λ Ceti; magnitude 4·7. On the 27th it was about the same. On the 29th 2–3 brighter than ν Ceti, 2 fainter than μ Ceti, and just about equal to ξ Piscium, magnitude 4·6. It seems to have remained at about this until January 21, when it was again estimated as on December 27, magnitude 4·7. It remained at this until February 1, when it was estimated at 1–2 brighter than ν Ceti, and certainly fainter than ξ Piscium, magnitude 4·8. It remained at about this until February 8. Bad weather then interfered until February 13, when it was estimated as 2–3 fainter than ν Ceti, 2 brighter than H.P. 363, and 2–3 brighter than H.P. 376 and 347; magnitude 5·3. On 14th about the same. The next and last observation was made on February 20, when it was estimated at 1–2 brighter than H.P. 376 and 347, and 1–2 fainter than H.P. 363; magnitude certainly below 5·5. All the comparisons were made with the naked eye, except on February 13 and 14, when the Moon being bright, and the star below the 5th, a small opera-glass was used, as time was lost in looking for it. On January 6 it was estimated as 3–4 brighter than ν Ceti, just about equal to ν Piscium, equal to ξ Ceti, and more than 5 steps fainter than α Piscium; but as the wind was very strong, the comparisons were somewhat uncertain.

I am satisfied, however, that taking ν Ceti as 4·9 magnitude, Mira never exceeded, if it quite equalled, a 4·5 magnitude star.

The "Companion" to 'The Observatory' gives the maximum as February 13; but I am pretty certain that the maximum occurred between December 29 and January 13. On February 13 the star was certainly below 5th magnitude. W. H. Numsen.

Baltimore, Md., U.S.A.,
1886, Feb. 25.

Proposed Change in the Astronomical Day.

Gentlemen,—

In reply to your question concerning the change of the beginning of the astronomical day from noon to midnight, it seemed to me worth while to obtain the opinions of gentlemen who are now, or who in recent years have been, connected with the practical work of this Observatory. Without any consultation with these astronomers, or argument, and without meeting together and discussing among themselves, they have voted as follows:—

Professor William Harkness	No.
Professor John R. Eastman	No.
Professor Edgar Frisby	No.
Assistant-Astronomer A. N. Skinner	No.
Assistant-Astronomer H. M. Paul..........	No.
Assistant-Astronomer W. C. Winlock	No.
Mr. Joseph A. Rogers	No.

No denotes opposition to the proposed change, and *Yes* would indicate that the voter is in favour of the change.

Now I submit that the opinion of the above astronomers on this question is of greater value than that of the admirals, generals, and diplomats who so largely formed the Conference that assembled in Washington in the autumn of 1884.

Naval Observatory, Washington,
1886, Mar. 10.

Yours, &c.,
Asaph Hall.

Transits of Jupiter's IVth Satellite.

Gentlemen,—

Perhaps the fact may have escaped the notice of some of your readers, that, owing to the position of Jupiter this opposition, the IVth satellite has missed transiting the disk of its primary on several occasions—notably during the months of January, February, and March, during which, however, the shadow has appeared as usual. The fact that there is no transit during these three months and yet the shadow is visible, is a rare event, so far as I can find, and did not occur in the preceding cycle twelve years since, or in the penultimate twenty-four years ago. It is to be regretted that the opportunity for observing the transits that take place this opposition in April, May, June, July, August, and September, occur at times which prevent their being seen at Greenwich, only two being partially visible—one on May 8th and the other on May 25th; for it would have been interesting to note the effects that the different illumination of the background produced in the appearance of the satellite in its transit over those portions of the disk where we are little accustomed to see such phenomena.

My object, however, in bringing this matter forward is to call the attention of observers to a phenomenon which, so far as I can find, is extremely rare, and which will occur, according to the 'Nautical Almanac,' on April 5th. At 11^h 49^m the shadow of the IVth satellite will be projected on the disk of Jupiter, but the satellite itself will probably be seen, not in transit, but to the north of its primary, that is, immediately beneath the disk of Jupiter, as seen through an inverting telescope. Observations should be commenced, however, some little time before the projection of the shadow, as it is not quite certain at what hour the satellite will be best seen.

If, now, the rotation of spots has anything to do with the dark transits, and if, as it is thought by several observers, including Herschel, Cassini, and others, these spots are turned to the Earth during the period when the satellite is in transit, then it is not unreasonable to expect that some expression of feebleness will be manifested in the appearance of the light reflected by the satellite when passing this portion of its orbit, which under other circumstances would have resulted in a transit across the disk of its primary. To those observers possessing a photometer the position of the satellite will be a very favourable one, inasmuch as the other satellites will be some little distance away, and the disturbing influence of the light of Jupiter will remain approximately constant during the time ordinarily occupied by the satellite in transit.

It may be worth adding in connection with the IVth satellite, the great importance of noting the complete eclipses, records of which are very rare. It has been stated that in the Greenwich observations of the satellites extending over 48 years, from 1836 to 1883, the number of eclipses of which both the beginning and the end have been observed is only five, none of which happened to be of service for correcting the latitude of the satellite. It seems that in every cycle of eclipses, the observations at the commencement and ending are especially those of importance, as a slight error in latitude shows itself so strongly and with such well-marked results. Mr. Todd, of Adelaide, in the 'Monthly Notices,' vol. xxxix., states that he saw the satellite running along the edge of the shadow reduced to a mere speck of light when it should have been eclipsed, according to the tables, for about 79 minutes. Another observation of a somewhat similar error was noticed by Bellamy in the 'Notices,' vol. xliii., as happening in 1883. If, then, as may be considered probable, the tabular value of the node of the satellite's orbit on the orbit of Jupiter requires some correction, the duration of the last eclipses as given by the tables may be found, not only too short, but, according to Mr. Marth, there may be an additional eclipse on May 17, not mentioned in them, and perhaps another on June 3. As the errors of the predicted times may amount to a quarter of an hour, observers must be prepared to look for the phenomenon early enough, and the same remark also applies to the reappearance. The approximate time of the eclipse on May 17 is about $11^h\ 26^m$ for the observatories of Europe.

I shall be greatly obliged to any observers who witness any changes in the appearance of the IVth satellite on April 5th, and who do not intend to make their observations a subject of special communication to any Society or periodical, to forward them to me at my address given below. Yours truly,

Ivy House, Clapham Common,
1886, March.

EDMUND J. SPITTA.

The Discovery of the Star-cluster 22 *Messier in Sagittarius.*

GENTLEMEN,—

Halley, in his "Account of several *Nebulæ* or Lucid Spots like Clouds, lately discovered among the Fixt Stars by help of the Telescope," in the 'Philosophical Transactions' for 1716 (vol. xxix. p. 391), after speaking of the great nebulæ in Orion and in Andromeda (the discovery of the latter he wrongly attributes to Bullialdus about the year 1661), says:—

"The Third is near the Ecliptick between the *Head* and *Bow* of *Sagittary*, not far from the point of the Winter Solstice. This it seems was found in the year 1665 by a *German* Gentleman, M. *J. Abraham Ihle*, whilst he attended the motion of *Saturn*, then near his *Aphelion*. This is small but very luminous, and emits a Ray like the former."

Sir W. Herschel, in giving an account of an observation of his own of this nebula (Phil. Trans. for 1800, vol. xc. p. 73), refers to it as having been discovered by Abraham Ihle in 1665, doubtless taking this from the above paper of Halley. Smyth, however, in the 'Celestial Cycle' (vol. ii. p. 422) states that "Hevelius appears to have noticed it previous to 1665;" and Arago ('Astronomie Populaire,' livr. xi. chap. iv.) says the same thing, but in all probability he merely copies Smyth (though he does not say so) in this.

Derham, in his "Observations of the Appearances among the Fix'd Stars, called *Nebulous Stars*" (Phil. Trans. for 1733, vol. xxxviii. . 70), gives a collected list of the nebulous stars observed by Hevelius, and found in his 'Prodromus Astronomiæ' (the date of which, it will be remembered, is 1690), but remarks that the objects mentioned by Halley, including the nebula in Sagittary, are not contained in it. (He should have excepted, however, the nebula in the girdle of Andromeda, now known to have been noticed, not only by Marius in 1612, but long before him by the Persian astronomer Sûfi, the discovery of which, as is mentioned above, was erroneously attributed by Halley to Bullialdus.)

It seems to me that it would be very interesting if any one could furnish any information about Abraham Ihle and his observation of this cluster. Smyth remarks, "It has been thought this name should have been Abraham Hill, who was one of the first Council of the Royal Society and was wont to dabble with astronomy." But surely this is a most improbable suggestion. For Halley must have known Abraham Hill, and could neither have given his name so erroneously as Ihle, nor called him a German gentleman. It would seem much more likely that he heard of the discovery whilst at Danzig in 1679–80, when he would doubtless have heard from Hevelius personally of all the discoveries which he had made up to that time.

Wolf, in his 'Geschichte der Astronomie' (p. 420), says, on the authority of Kirch, that the discovery of the nebula in Sagittarius was made in the year 1665, "by Abraham Ihle, an otherwise unknown astronomical amateur, who was probably in some way connected with Hevelius, as this discovery has frequently been ascribed to him." As for Hill (who was born in London in 1633, and died at Sutton-at-Hone, Kent, in 1721), he became Treasurer of the Royal Society in 1663; Halley must have known him personally, and the suggestion that he ascribed what was due to him to "a German gentleman named Ihle," must be pronounced absurd.

Yours faithfully,

Blackheath, 1886, Mar. 10. W. T. Lynn.

Nebulæ observed by Hevelius in Hercules.

Gentlemen,—

Smyth, in his 'Celestial Cycle' (vol. ii. p. 385) says that Hevelius, in his 'Prodromus Astronomiæ,' speaks of a nebula at the top of the head of Hercules (near, therefore, to α Herculis), which Messier searched for in vain; and as the nearest nebula to that star was beyond the power of the telescope used by Hevelius, he suggests that the object was really a comet. This suggestion is quoted by Chambers ('Descriptive Astronomy,' 3rd edition, p. 430), with the remark that he had not succeeded in recovering the statement of Hevelius.

It will be found, however, at pp. 207 and 289 of the 'Prodromus,' in the Catalogues of Fixed Stars there given, arranged in constellations. Under "Hercules," we find "In Vertice trium Nebulosarum infer. major," which I presume signifies that the place given (both in longitude and latitude, and in right ascension and declination, for 1660) refers to the larger of three nebulæ, of which the other two are higher (than the top of the head), and therefore beyond the boundary of the constellation.

In the 'Connoissance des Temps' for 1784 we are told that "Le 20 Juin 1764, par un beau ciel, M. Messier a cherché cette nébuleuse, sans pouvoir la découvrir." It would almost seem as if Messier had overlooked the fact that not one nebula, but three nebulæ are mentioned by Hevelius. He goes on to speak of four nebulæ given by Hevelius near the eye of Capricornus, which he searched for "sans pouvoir les découvrir, et il doute qu'elles existent." Only three of these four appear to be marked in Hevelius's maps of the constellations, and it is not quite certain whether he means to refer to three or four; *i. e.* whether the fourth object "supra Nebulosas ad Oculum," is intended to be a nebula or a star.

But the point to which I wish to call attention is, that although one nebula found to be missing in Hercules may have been a comet, that cannot have been the case with three, so that Smyth's conjecture falls to the ground, and there must have been some other mistakes in the nebulæ given by Hevelius, both in Hercules and in Capricornus.

Yours faithfully,
W. T. LYNN.

Blackheath, 1886, Mar. 15.

The Red Spot on Jupiter and its Junction with a Dark Southern Belt.

GENTLEMEN,—

I made no observations of Jupiter during the prolonged frost, but on March 23 directly I examined the planet (about 11^h 15^m) I saw the red spot was joined to a dark belt on its south side, as in Jan. and Feb. 1884 and on May 9, 1885. With power 252 on my 10-inch reflector the connection was extremely plain. Mr. N. E. Green (to whom I immediately wrote on the subject) has also seen it with great distinctness both on March 21 and 23, with a power of 280 on his 18-inch reflector. He mentions that though he examined the region of the red spot very carefully to see if any separation existed between the spot and belt, he could find none. Mr. Green has also favoured me with an outline sketch of the appearance on March 23, and it agrees exactly with one executed by myself at the same time.

I trust other observers will look for this interesting detail and that Professors Hough and Pritchett will have no further difficulty in detecting it.

Yours faithfully,
W. F. DENNING.

Bristol, 1886, Mar. 25.

NOTES.

The Binary Star β Delphini *.—Mr. J. E. Gore has computed an orbit of this rapid binary by the method explained in Crossley, Gledhill, and Wilson's 'Handbook of Double Stars.' It will be remembered that in 1873 Mr. Burnham discovered that the primary star of this long-known wide double was itself a very close double, and it has been observed pretty regularly since then, the observation from which the orbit is deduced extending from 1874·66 to 1884·71. Mr. Gore fixes the periastron passage at 1882·25, with eccentricity 0·337 and period 30·91 years. As the semiaxis major is only 0″·517, this object is beyond the reach of small telescopes, and is therefore chiefly interesting on account of the rapid motion of the companion. The orbit of β Delphini was computed some time ago by Herr Dubiago, who found the time of periastron passage to be 1882·19, eccentricity 0·3567, and period 26·07 years, so that Mr. Gore's computations give a result in fair agreement with those of the Russian astronomer.

Dark Transits of Jupiter's Fourth Satellite.—Prof. George Davidson has communicated to the California Academy of Sciences, notes of observations of dark transits of this Satellite made by Mr. Burckhalter on May 21 and on June 7, 1885, and by himself also on the latter date. Observing with his 10½-inch reflector on May 21, Mr. Burckhalter saw Satellite IV. as a bright point on its approach to the planet, but when it had advanced some way on the disk it appeared dark. Prof. Davidson remarks that this observation suggests the possibility that the satellite has an area of white surface and also an area of dark surface, the white part being lost in the superior brightness of the planet, as the transit proceeded, and the dark area then becoming visible. He thinks that it might even lead to the determination of the rotation period of the satellite if it were watched throughout the entire transit to detect its phases to the end. Again observing on June 7, Mr. Burckhalter saw Satellite IV. as a dark spot on the edge of the north dark belt. It was particularly noticed that the north hemisphere of the satellite was apparently the darker. When, however, the satellite moved off the disk, the observer noted that it was north of the dark belt; so that it would appear as if the satellite is divided into bright and dark areas, the south pole being the dark one. On the same evening Prof. Davidson, using a 6·5-inch refractor, also saw the satellite as a small black spot on Jupiter's disk traversing along the apparent lower edge of the belt where it was relatively dark. When the satellite was leaving the planet it appeared lower than the prolonged line of its passage as a dark image would have indicated; as if the dark image were nearer the equatoreal line of Jupiter, and the bright image toward the pole. A reasonable inference from this observation also is that the face of the satellite presented to the observer was in part dark and in part bright. Prof. Davidson states that a similar property in the case of Satellite III. was exhibited on Jan. 15, 1884 ('Observatory,' vol. vii. p. 176).

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* Proceedings Royal Irish Academy, 2nd ser. vol. iv. no. 5 (Science).

AN OBSERVATION OF NEPTUNE OCCURRING IN LAMONT'S ZONES*.—Prof. Schönfeld points out that the object numbered 3818 in the Munich Supplementband xii. (Lam.) is really the planet Neptune. The observation from which the Catalogue place is deduced was made on September 11, 1846. Two other cases of observations of Neptune occurring in Lamont's Zones were pointed out by Mr. Hind in 'Astron. Nachrichten,' No. 712, the dates of observation being respectively October 25, 1845, and September 7, 1846. The date of the optical discovery of Neptune by Galle was September 23, 1846. It is desirable that such cases as these should be put on record, in order that observers may be saved from the mistake of thinking that, from not finding objects corresponding to these Catalogue places, they have lighted upon instances of "temporary" stars.

ELEMENTARY STAR ATLAS.—This atlas, by the Rev. T. Espin, comprises the twelve maps published in the 'Illustrated Science Monthly' for 1884. A preface by Westwood Oliver, intended to encourage amateurs, contains some practical and pertinent remarks. We would, however, like to know to whom he refers when he states:—"They consider him to be the greatest astronomer who sits at the end of the biggest telescope." Again, we believe Neptune *was* viewed by mortal eye long before Adams was born. The letterpress description accompanying each map is well worth the attention of amateurs, and the "Hints" are practical; but with the maps themselves we are much disappointed. From an artistic point of view they have nothing to recommend them: the map for August forcibly reminds us of our school-days, when we competed with our neighbour in making the biggest blots by sticking pens in a piece of paper, and the graphical method adopted to represent the different star magnitudes is bewildering and lacks consistency. The blots are too large, the diamond-shaped patches disfigure the map and serve no useful purpose. As no one map is independent of the others, the want of consistency is unpardonable. Take, for instance, the map for October, where the area representing a 7th mag. star is only one sixth the corresponding area in the April map, in which the 7th mag. is represented as large as the 6th mag. on any other map. Or taking two successive maps, such as February and April, we find that a 4th, 5th, or 6th mag. on the one is really shown as a 6th, 7th, or 8th respectively on the other. Amongst so many mistakes it is difficult to particularize, but we cannot pass over the case of the Pleiades. This group is shown on three separate maps, and is made up in November of four sixth mags. and one third mag.; in December by three fifth, one fourth and one third; while in February we get two sixth, three fifth and one fourth. The most distinctly marked constellations are with difficulty recognizable, which is unfortunate for the beginners on whose account the maps are in existence.

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* Astron. Nachr. No. 2716.

THE STAR-GUIDE*.—The main portion of this little work, which is intended to serve as an introduction to the sidereal part of Webb's 'Celestial Objects for Common Telescopes,' contains a list of nearly 600 of the most interesting and beautiful objects visible in the northern heavens with instruments of from 2 to 4 inches aperture, arranged in a tabular form in order of right ascension. The authors hope that this list will be found to contain nearly every double star between the North Pole and 15° south declination which can be easily seen with an achromatic of small aperture. The Greenwich mean times of transit of these objects are given for each 10th day in the year, as also the limiting months during which each is visible in these latitudes. This list is followed by another containing the positions of about 200 objects which can be seen with refractors of from 4 to 7 inches aperture, arranged in substantially the same way as the preceding one. With regard to these lists, it may be sufficient to remark that every observer, professional or amateur, has, or ought to have, the 'Celestial Objects:' and this being premised, it is difficult to see what useful purpose could be served by a beginner devoting his attention to the objects specified in the 'Star-Guide,' considered as an introduction to Webb's far-famed work, instead of going directly to the latter. The limitation of the range of declination of objects (as stated above) also limits the applicability of the book in latitude. We, however, think that in English astronomical works the wants of observers in the English colonies should be considered and supplied as far as possible. If this were done habitually, we might hope soon to have the southern skies as thoroughly explored as have been the northern heavens.

The most valuable section of the work, in our opinion, is that dealing with Test-objects. The stars contained in these lists have been divided into three kinds of tests, viz., dividing tests, defining tests, and space-penetrating tests. The double stars suitable for each kind of test are arranged in descending order of difficulty, separate lists being given as applicable respectively to various apertures, ranging from 2 to 7 inches inclusive. The limit of the separating power for an aperture of a inches is taken from Dawes' formula, viz., $\frac{4''\cdot 56}{a}$. These lists appear to be arranged with skill and judgment, and will be most useful to those who have to test small refractors. The remainder of the book is taken up with information respecting Lunar Craters; whilst in the Appendix we have ephemerides of a few variable stars for 1886, positions of the Lunar Terminator for each midnight from Nov. 1, 1885, to Dec. 31, 1886, and the Comets of 1886.

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* The Star-Guide: A List of the most remarkable Celestial Objects visible with small Telescopes, with their Positions for every tenth day in the year, and other Astronomical Information. By Latimer Clark, F.R.A.S., and Herbert Sadler, F.R.A.S. London: Macmillan and Co., 1886.

The price of the 'Star-Guide' is five shillings—rather excessive, we fancy, for a book of 48 pages, some of the matter of which is applicable to the current year only.

POTSDAM OBSERVATORY.—The first part of the fourth volume of the Publications of the Astrophysical Observatory of Potsdam has recently been published. It contains three sections:—Observations with the great refractor of the Vienna Observatory by Prof. H. C. Vogel; Meteorological Observations made in the years 1881 to 1883 by P. Kempf; and a memoir on the Influence of Temperature on the Refraction of Light through different kinds of glass, Iceland spar, and rock-crystal.

The first section contains Prof. Vogel's opinion of the performance of the Vienna refractor. His first impression, based upon his experiences during some exceedingly clear weather in the spring of 1883, was that the object-glass was a fairly good one, but that the images were not by any means so sharp as those of middle-sized instruments, and he therefore concluded that the difficulty of producing such large objectives had not been fully overcome, and that their advantage over smaller instruments consisted mainly in their greater light-gathering power. But on returning to Vienna in the autumn he was compelled to reconsider this conclusion, and he states that "the Vienna refractor, as regards the precision of the images, leaves nothing to be desired." "I have," he goes on to say, "on splendidly clear evenings in September, used a power of 1000, and even of 1500 with advantage, and perceived the fine details of planetary disks with admirable sharpness. The images of bright stars were of perfect regularity, and the central part of the diffraction disk was so remarkably small that it may be expected that the instrument will also be very well suited for the observation of double stars."

The observations printed in this section are chiefly spectroscopic, Prof. Vogel having employed the great light-gathering power of the Vienna refractor in order to obtain accurate measures of the positions of the bands and lines in the spectra of several faint stars which are of unusual appearance. Amongst these are Arg. Oeltzen 17681, Lal. 13412, DM. +35° No. 4001, +35° No. 4013, +36° No. 3956, all five of which show bright lines. Several striking examples also of Secchi's fourth type were examined, and a table is given of the positions of the dark bands and lines in their spectra. "The characteristic bands of these stellar spectra" are due to the absorption of hydrocarbons in their atmosphere.

Some drawings of planetary nebulæ follow, and the section concludes with a view of part of Saturn's ring as seen with a power of 1500. The volume contains five plates, of which two are merely diagrams. Of the other three plates, two contain drawings of certain nebulæ, and the third the spectra of seven faint stars. These are all beautifully executed.

STELLAR PHOTOGRAPHY [*].—The results which the Brothers Henry have obtained with their instrument for stellar photography [†] have more than fulfilled the highest expectations. Amongst the more remarkable of their achievements are the following:—1. The discovery of a nebula near the Pleiad Maia. This nebula was invisible to the eye in the equatoreals of the Paris Observatory, but has since been seen with the great refractor of the Pulkowa Observatory, and likewise at Nice. Prof. Pickering has also found that it had recorded itself on a photographic plate exposed at Harvard College, on Nov. 3, 1885; but it was supposed at the time to be merely a defect in the film [‡]. 2. Good photographs of the principal planets have been obtained, those of Saturn being especially fine, the principal division of the ring, which is 0″·4 in breadth, being distinctly visible. 3. The satellite of Neptune has been photographed in all parts of its orbit, even at the point of nearest approach to its primary. 4. Stars of the 16th, and even of the 17th, magnitude, which have never been directly seen, have been photographed. Forty-two fine plates have been obtained of the Milky Way and other regions of the sky. More than 600 double or multiple stars have been photographed, besides the star-clusters of Hercules, Sobieski, Ophiuchus, and Perseus. 5. A two hours' exposure on the nebula of Orion has brought out the faintest details with great distinctness. 6. Lastly, results not less remarkable have been obtained in spectrum photography.

The above brief recapitulation of some of the principal results already achieved will suffice to give an idea of the splendid success which has already attended MM. Henry's efforts, and of the great and almost illimitable harvest which we may well hope to reap in the near future.

But the photographs must themselves be seen in order to fully appreciate their beauty and distinctness. It may, however, be added that their definition is so sharp that some people have even been led to suggest that they must have been photographed from engravings. The photographic apparatus of MM. Henry is so free from distortion, that on a photograph of 3° in diameter it is absolutely insensible; and it is only necessary to rule the lines of declination and right ascension on the plates for them to become perfectly finished star-maps.

M. Cruls, director of the Rio de Janeiro Observatory, has been commissioned by the Emperor of Brazil to have a photographic apparatus constructed similar to that devised by the Brothers Henry at Paris, in order to cooperate with them in the proposed photographic survey of the heavens. The Observatory at the Cape of Good Hope has already commenced similar work.

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[*] 'Comptes Rendus,' Vol. cii. No. 3.

[†] 'Observatory,' Vol. v.

[‡] Astron. Nachr. No. 2712.

MOTION OF THE SOLAR SYSTEM IN SPACE.—Herr Homann has recently discussed the results of various observations of the motions of stars in the line of sight, for the purpose of determining the direction and speed of the motion of the solar system in space, and has published his results in the 'Astronomische Nachrichten,' No. 2714. Three series of observations were at his disposal, those of Dr. Huggins and Mr. Seabroke, and the series obtained at Greenwich Observatory. The two former contained but few stars, and those only seldom observed; but as a matter of interest he has discussed them as well as the Greenwich series. The following are the results obtained:—

Series.	Velocity of Translation. Kilometres per sec.	Apex of Solar Motion. R.A.	Apex of Solar Motion. Dec.
Greenwich	39·3 ± 4·3	320·1	+41°·2
Huggins	48·5 ± 23·1	309·5	+69 ·7
Seabroke	24·5 ± 15·8	278·8	+13 ·6

It will be observed that the differences between the three results are very considerable, but perhaps not greater than might fairly be expected when the difficulty and paucity of the observations are borne in mind. All three agree in placing the apex considerably in advance in R.A. of the apex, as found from the proper motions of stars by Struve, Airy, Dunkin, and others, whilst Struve found the velocity of translation to be only about 7 kilometres per second. This latter determination was, however, based upon the assumption that the average annual parallax of stars of the first magnitude was about 0″·25, an assumption which may well be greatly in excess of the truth. Herr Homann considers that we may consider the velocity of translation as not greatly differing from 30 km. per second. Probably, however, the spectroscopic method is not yet ripe for such an investigation to be satisfactory. We cannot be said to know, even roughly, the rate of motion in the line of sight of more than fifty stars, and these are situated almost without exception in the northern hemisphere. Nor are they evenly distributed over that hemisphere, but are massed in three or four groups, so that should any one of these groups form a connected system with a common proper motion, not an unlikely contingency, any result must be affected by a large error. A series of good southern observations is the great desideratum in this branch of the science.

THE NEW STAR IN THE NEBULA IN ANDROMEDA *.—Prof. Seeliger has published an interesting paper containing an attempt to represent the observed variations of the light of the *Nova* in Andromeda by a formula expressing the rate of cooling of a hot sphere. Supposing that such a body has, owing to some shock, its temperature suddenly increased to an enormous extent, its brightness will of course be increased also. And assuming that the latter is proportional to the *n*th power of the temperature, and using Pogson's scale for transforming brightness into stellar magnitude, Prof. Seeliger (making some further more or less probable assumptions) deduces an expression for the magnitude of the cooling star at any time. In order to compare this formula with Herr Müller's photometric measures of the *Nova*, extending from 1885 Sept. 2 to Oct. 13, Prof. Seeliger assumes that $n=1$, and that the epoch for which the time $t=0$ is 1885 Aug. 27^d 8^h Berlin M.T. Using quite approximate values of the constants involved in his formula, it appears that there is a good general agreement (the mean discordance being 0·11 of a stellar magnitude) between the computed and observed values. The computed magnitude corresponding to the epoch for which $t=0$ is 7·73. The fair agreement shown by this comparison induces Prof. Seeliger to think that the form of the expression which he has deduced is such as would accurately represent the observations, provided that it were possible to determine the necessary constants with sufficient precision. And as there is evidence to show that the nebula in Andromeda is, partly at least, composed of a vast number of faint stars, it appears, in Prof. Seeliger's opinion, not unreasonable to suppose that a collision was the cause of the sudden development of heat and light which revealed itself to us as the appearance of a "new" star.

With reference to the point thus raised by Prof. Seeliger, Herr Auwers points out † that the great similarity of the outburst in Andromeda in 1885 to the phenomenon observed by him in 1860 in the cluster 80 Messier in Scorpio is a strong confirmation of Prof. Seeliger's views. The probability that two variable stars, of such exceptional character, should be projected, in one case on a close star-cluster, in the other case on an object which appears to be, in part at least, a close star-cluster, is so small that it is almost necessary to refer these outbursts to physical changes in the nebulæ in which they respectively appeared. It will be remembered that Herr Auwers discovered a 7th-magnitude star in the cluster 80 Messier on the evening of May 21, 1860. By June 16 the light of the *Nova* had diminished to that of a star of the 10·5 magnitude. The new star in Scorpio was independently discovered in England by Mr. Pogson on May 28, 1860.

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* Astron. Nachr. No. 2710.

† Ibid. No. 2715.

HARVARD COLLEGE OBSERVATORY.—Prof. Pickering has published the Annual Report of the Harvard College Observatory for the year 1885. Notwithstanding the unsatisfactory financial position in which the Observatory stands, and which has necessitated a reduction in the staff of observers, the usual photometric and meridian observations have been carried on with vigour. The great zeal and energy displayed by the assistants have alone rendered this possible. With the east equatoreal the photometric observations of the eclipses of Jupiter's satellites have been continued. An extensive series of photometric observations of stars have been made with the wedge photometer attached to this equatoreal. The resulting magnitudes have been computed by means of the stars which are also under observation with the meridian photometer, the work of the wedge having in this way been made homogeneous with that of the latter instrument. The extensive use thus made of the wedge photometer seems to show that the instrument used at Harvard College is not capable of the great degree of precision which is claimed for that employed by Prof. Pritchard. To determine whether this difference is due to the form of the instrument, Prof. Pritchard has kindly undertaken to superintend the construction of a wedge photometer made upon his plan. With the meridian circle, in charge of Prof. Rogers, the observation of a Polar Catalogue has been commenced. The total number of observations during the year was 2808, including 1003 observations of fundamental stars.

The meridian photometer has also been actively employed. The list of stars to be observed has been somewhat extended, so that the entire series includes zones at intervals of 5° from the equator to the pole. The system adopted ensures the regular distribution of stars to be observed down to the ninth magnitude. An important investigation has been undertaken in stellar photography. A Voigtlander portrait-lens of 8 inches aperture and 44 inches focus has been mounted equatoreally. With this instrument photographs have been taken of the trails left by stars when the telescope is not driven by clockwork. Equatoreal stars of the sixth, and polar stars as faint as the fourteenth magnitude have thus been photographed. Most striking results have thus been obtained with stellar spectra. By placing a large prism in front of the lens, photographs have been obtained of stars as faint as the eighth magnitude, in which lines are shown with sufficient distinctness to be clearly seen in a paper positive. Prof. Pickering expresses his obligation to his brother, Mr. W. H. Pickering, who has rendered important aid in this investigation, especially in the photographic process.

AMERICAN DETERMINATIONS OF THE VELOCITY OF LIGHT [*].—Prof. Newcomb has now published the details of his researches on the velocity of light, along with a second determination of the same physical constant made by Prof. Michelson. Both these scientists have adopted modifications of Foucault's revolving-mirror apparatus for the purpose of this investigation. The final results for the velocity of light *in vacuo* expressed in kilometres per second are:—

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[*] 'Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac,' Vol. ii. Parts iii., iv.

Michelson in 1879	299910
Michelson in 1882	299853
Newcomb in 1882, using only results supposed to be nearly free from constant errors......	299860
Newcomb, including all determinations	299810

Prof. Newcomb thinks that we may conclude, as the most probable result, that the velocity of light *in vacuo* is 299860 km. ± 30 km. Adopting Nyrén's value of the constant of aberration, viz. 20″·492, and Clarke's value of the Earth's equatoreal radius, this gives for the solar parallax the value 8″·794. With regard to the question which has been raised by Messrs. Forbes and Young, as to a possible difference between the velocities of rays of different colours, it is pointed out that the phenomena of variable stars seem to be conclusive against the hypothesis of any such difference. Were there a difference of one hour in the times of the blue and red rays reaching us from Algol, this star would show a well-marked coloration in its phases of increase and decrease. No such effect, however, has been noticed; and as the parallax of this star is probably less than 0″·1, it is difficult to see how there can be a difference as great as four parts in a million between the velocities of light coming from near the two ends of the bright part of the spectrum. Prof. Newcomb is certain that had there been a difference of one-thousandth it would have been easily recognized in his velocity-of-light apparatus. No trace of such could ever be seen. Some experiments made by Prof. Michelson to elucidate this point have also led him to the same negative conclusion.

UNIVERSAL TIME.—The Astronomer Royal delivered a lecture on Universal Time at the Royal Institution on March 26. The purpose of the lecture was to set forth the advantages which would be secured by the adoption all over the world of the same standard of time, and to urge the selection of the particular standard recommended by the Washington Conference, viz. the Greenwich Civil Day. The lecturer laid great stress on the incompatibility of retaining an indefinite number of local times with our present state of progress; a system which caused but little inconvenience in the days of stage-coaches was intolerable in these of railroads and telegraphs. The various countries of Europe had therefore each adopted a uniform time throughout their borders, but the great extent of the United States rendered the question a more difficult one there. Finally, five different standards have been adopted, each differing by an exact number of hours from Greenwich Time, instead of the 75 standards which prevailed before. The lecturer then traced the history of Mr. Sandford Fleming's proposals for a universal time standard which resulted in the Washington Conference. The advantages of the system recommended by the Conference for railway travelling and for telegraphing were next dwelt upon, and it was stated that its adoption would save the telegraphing of 150 millions of letters annually. The difficulties in the way of such adoption were referred to, but not judged to be serious, and a number of ingenious devices for showing universal and local time on the same dial were exhibited.

THE CHANGE IN THE ASTRONOMICAL DATE.—For astronomers the important point of the Astronomer Royal's lecture was the statement that the Board of Visitors of the Royal Observatory had recommended the adoption, in the 'Nautical Almanac' for 1891 and following years, of Greenwich Civil Time—reckoning, that is, from Greenwich mean midnight to midnight and counting from 0 to 24 hours, in accordance with Resolution VI. of the Washington Prime Meridian Conference, which expresses the hope that, as soon as may be practicable, the astronomical and nautical days will be arranged everywhere to begin at mean midnight.

WE regret to announce the death, after a very severe illness, of Mr. Charles George Talmage, F.R.A.S., which took place on March 20 at Knots Green, Leyton. Mr. Talmage was born on Nov. 12, 1840, and commenced his astronomical career at the Royal Observatory, Greenwich, in the year 1856. In 1860 he joined Mr. Hind as assistant at Mr. Bishop's observatory in the Regent's Park. He then went to Nice for four years, where he was engaged in Double-Star observations. At the conclusion of that work, which was a re-examination of Admiral Smyth's Bedford Catalogue, Mr. Talmage again joined Mr. Hind at the Observatory at Twickenham. In 1865 he was appointed Director of the private Observatory of Mr. J. G. Barclay at Leyton, which appointment he held up to the time of his death. In 1870 he was sent to Gibraltar to observe the Total Solar Eclipse, and in 1882 he was appointed officer in charge of the West-Indian Expedition for observing the Transit of Venus. Mr. Talmage was so well known and respected in the scientific world that his untimely death will be regretted by a large circle of friends.

WE likewise regret to announce the death, on Feb. 16, of Mr. Thomas Bassnett, of Jacksonville, Florida, in the 79th year of his age. Mr. Bassnett was a native of Lancashire, but emigrated early in life to the United States. He was an ardent lover of science, and to the very close of his long life took an active interest in the progress of astronomy.

Ephemeris for Comet Fabry[*].

By Dr. H. Oppenheim.

(From the elements published in the 'Observatory,' No. 108, p. 143.)

For Berlin Midnight.

	R.A.			Dec.				Bright-
1886.	h	m	s	°	′	Log *r*.	Log Δ.	ness.
Apr. 4..	23	20	55	+38	58·9	9·8043	9·9198	45
6..	23	23	29	39	16·5			
8..	23	27	4	39	28·7	9·8062	9·8547	61
10..	23	31	58	39	34·2			
12..	23	38	33	39	31·4	9·8157	9·7767	83
14 .	23	47	17	39	17·2			
16..	23	58	48	38	46·9	9·8317	9·6825	118
18..	0	13	47	37	53·4	9·8417	9·6282	145
20..	0	33	27	36	24·0	9·8527	9·5686	181
22..	0	58	58	33	58·3	9·8645	9·5043	230
24..	1	31	39	30	2·6	9·8770	9·4370	297
26..	2	12	8	23	52·1	9·8899	9·3726	376
28..	2	59	25	14	52·2	9·9031	9·3229	445
30..	3	50	0	+ 3	37·0	9·9165	9·3042	456

The brightness on 1885 Dec. 2 is taken as unity.

Ephemeris for Comet Barnard[†].

By Dr. H. Oppenheim.

(From Dr. A. Krueger's elements published in the 'Observatory,' No. 107, p. 112.)

For Berlin Midnight.

	R.A.			Dec.				Bright-
1886.	h	m	s	°	′	Log *r*.	Log Δ.	ness.
Mar. 31..	1	50	22	+30	45·4	9·9509	0·2006	11
Apr. 4..	1	49	33	32	15·9		0·1868	
8..	1	48	25	33	49·1	9·8776	0·1699	18
12..	1	46	58	35	23·8		0·1494	
16..	1	45	6	36	57·3	9·7962	0·1245	32
20..	1	42	50	38	25·0		0·0941	
24..	1	40	23	39	38·9	9·7188	0·0568	62
28..	1	38	22	40	26·0		0·0111	
May 2..	1	38	8	+40	28·4	9·6796	9·9556	118

The brightness on 1885 Dec. 5 is taken as unity.

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[*] Astron. Nachr. Nos. 2711, 2712.

[†] Ibid. No. 2714.

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E OBSERVATORY,

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E. W. MAUNDER, F.R.A.S.,
. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Royal Astronomical Society on April 9 177
Liverpool Astronomical Society 187

Spot and the Region near. By W. F. Denning, F.R.A.S. 188

nce :—
ry of the Great Nebula in Andromeda. By W. T. Lynn, B.A.,
s. 192
y and the Pleiades. By B. J. Hopkins, F.R.A.S. 194
e Star η Argûs. By John Tebbutt, F.R.A.S., and A. Stanley
ns, F.R.A.S. 194, 195

al Light.—Relation of Asteroid Orbits to that of Jupiter.—
on Formulæ.—A French Edition of Oppolzer's Treatise on Orbits.
onomical Directory.—The Binary Star 70 Ophiuchi.—The U.S.
Observatory.—The Proposed Change in the Astronomical Day.—
Main Nebula.—The Reliability of the Star-places of Auwers' Fun-
ntal Catalogue.—Photograph of the Normal Solar Spectrum.—
graphic Study of Stellar Spectra: Henry Draper Memorial.—
lax of Nova Andromedæ.—The Great Melbourne Reflector.—
lon Observatory.—The Secular Nutation of the Earth's Axis.—
Belgian Observatory.—Observations of Jupiter and Venus in
-85 by Dr. L. de Ball at Liége.—Four new Minor Planets.—Gift of
servatory to Liverpool College.—Discovery of a New Comet... 196–208

of Comet Fabry. By Dr. S. Oppenheim 208
of Comet Barnard. By Drs. H. Oppenheim and Hepperger 208

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THE OBSERVATORY,

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Edited by E. W. Maunder, F.R.A.S., A. M. W. Downing, M.A., F.R.A.S., and T. Lewis, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpool Astronomical Societies; Articles by various eminent Astronomers, English, American, and Continental; Correspondence on topics of interest connected with the Science; Notes on the progress of Astronomy; Reviews of astronomical publications; Ephemerides of comets, variable stars, Saturn's satellites, and for physical observations of the Sun, Jupiter, &c.; and all the usual astronomical information.

Amongst the contributors to 'The Observatory' in 1885 were Professors Asaph Hall, Holden, Hough, Pickering, Pritchard, and Young; Dr. Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs. Barnard, Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"—*Bulletin Astronomique* (organ of the Paris Observatory).

CONTENTS OF No. 109.

PAGE

Meeting of the Royal Astronomical Society on March 12, 1886 145

Articles:—

On the General Values of the Obliquity of the Ecliptic, and of the Precession and Inclination of the Equator to the Invariable Plane, taking into account Terms of the Second Order. By Prof. J. C. Adams, M.A., F.R.S. 150

The Geminids of 1885. By W. F. Denning, F.R.A.S. 154

The Nova and Nucleus of the great Andromeda Nebula. By the Rev. T. E. Espin, B.A., F.R.A.S. 156

Elements of Comet Barnard, 1886. By J. Morrison, Ph.D., F.R.A.S. 157

Maxima and Minima of Variable Stars observed during 1885. By Joseph Baxendell, Jun. 158

Maxima and Minima of Variable Stars observed during the Year 1885. By Joseph Baxendell, F.R.S., F.R.A.S. 159

Correspondence:—

Mira Ceti. By W. H. Numsen 160

Proposed Change in the Astronomical Day. By Prof. Asaph Hall, For. Assoc. R.A.S. 161

Transits of Jupiter's IVth Satellite. By Edmund J. Spitta, F.R.A.S. 161

The Discovery of the Star-cluster 22 Messier in Sagittarius. By W. T. Lynn, B.A., F.R.A.S. 163

Nebulæ observed by Hevelius in Hercules. By W. T. Lynn, B.A., F.R.A.S. 164

The Red Spot on Jupiter and its Junction with a Dark Southern Belt. By W. F. Denning, F.R.A.S. 165

Notes:—

The Binary Star β Delphini.—Dark Transits of Jupiter's Fourth Satellite.—An Observation of Neptune occurring in Lamont's Zones.—Elementary Star Atlas.—The Star-Guide.—Potsdam Observatory.—Stellar Photography.—Motion of the Solar System in Space.—The New Star in the Nebula in Andromeda.—Harvard College Observatory.—American Determinations of the Velocity of Light.—Universal Time.—The Change in the Astronomical Date.—Obituary: C. G. Talmage, F.R.A.S., and Mr. T. Bassnett 166–175

Ephemeris for Comet Fabry. By Dr. H. Oppenheim 176

Ephemeris for Comet Barnard. By Dr. H. Oppenheim 176

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 110. MAY. 1886.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, April 9, 1886.

J. W. L. GLAISHER, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. KNOBEL, and
Lieut.-Col. G. L. TUPMAN.

THE Minutes of the previous Meeting were read and confirmed.

Col. Tupman announced the receipt of 54 presents since the last Meeting. There were some fine drawings of Jupiter presented by Mr. Todd, of Adelaide; two drawings of Jupiter, one of Saturn, and one of the Great Orion Nebula by Mr. Tarrant; a catalogue by Mr. Franks of 1730 coloured stars; and an old legal document bearing the signature of Mr. Chester Moor Hall, who was the inventor of the achromatic telescope, a quarter of a century before Dollond, which had been presented to the Society by Mr. R. B. Prosser, of the Patent Office.

The President. I would ask the Meeting to return thanks to the donors of these presents, and especially to Mr. Franks for the catalogue of coloured stars, and also to Mr. Tarrant and Mr. Todd for their drawings, and to Mr. Prosser for the autograph of Chester Moor Hall. As Mr. Hall's connection with the achromatic telescope is not very generally known, I will call on Mr. Ranyard to tell us something about it.

Mr. Ranyard. The facts are very simple. It has long been known that some seven years after the patent was granted to Dollond for the invention of his achromatic telescopes, his claim to the invention was disputed, and a Mr. Champness, an instrument maker in Cornhill, infringed the patent, urging that Moor Hall had made such telescopes many years before the date of Dollond's patent. John Dollond was then dead, and his son brought an action against Champness. The report of the case is lost, but the facts are referred to in the reports of later cases. It appears that witnesses were brought forward who stated that they had made achromatic object-glasses as early as 1733. Dollond's patent was, however, not upset. Some few years ago I put together all the facts at which I could get with respect to Moor Hall, and Mr. Prosser, the gentleman who has given this document to the Society, thought that further information might be obtained in the neighbourhood where Mr. Hall had lived, and he therefore wrote a letter to a Colchester paper asking if any local antiquary knew anything further. By this means he learned that Mr. Hall was a Bencher of the Inner Temple, and must probably have been in London at the time of the action, though he did not appear as a witness. He was a man of some property, but does not seem to have been a Fellow of the Royal Society, though he must have known of Dollond's receiving the Copley medal. In pursuing these enquiries Mr. Prosser obtained the present document, which he has given to the Society, and which the Council has ordered to be framed and suspended in the Council-room. The matter is one of great interest, as the invention of the achromatic object-glass was a most important step in the progress of astronomy.

Mr. Knobel. Is there any object-glass by Mr. Hall known to be in existence?

Mr. Ranyard. No; but there was one as late as 1790. It is mentioned in the 'Gentleman's Magazine' as being in the possession of the Rev. Mr. Smith, of Rathbone Place. The glass consisted of three lenses and was of very short focus; I think 2½ in. aperture and 20 in. focal length.

Mr. Chambers. I think materials exist for carrying the investigation further. Some fifteen years ago I ascertained that Mr. Hall's property, which was near Harlow, in Essex, was in the hands of Mr. Watlington, M.P. for South Essex, and that this gentleman had succeeded in gleaning some further information respecting Mr. Hall.

Mr. Ranyard. I have corresponded with Mr. Watlington, but could obtain no information beyond the date of Mr. Hall's death.

The President. This is a subject of peculiar interest just now, as there seems to be a hope of still further improving the telescope.

A vote of thanks was passed to the donors.

Mr. Knobel read a paper by *Mr. David Gill*, "On some suggested improvements in the practical working of M. Loewy's new method of determining the elements of astronomical refraction." The paper commenced by a statement of M. Loewy's method, which is described in the 'Observatory' for February, vol. ix. p. 105. Mr. Gill, however, proposed some modifications of M. Loewy's method which promised increased ease of working and more general accuracy and utility. He proposed that the prism in front of the object-glass should be rigidly attached to the mounting of the latter, that a spider-line micrometer should be placed parallel to the line of intersection of the reflecting surfaces, and a rotation of the whole tube around its own axis effected by placing it in a suitable cradle.

Supposing two stars to be brought into the field of view, then by a very small movement of the position-circle the images could be brought into line with the direction of measurement, and their distance apart could be measured by the micrometer with the greatest facility. The altitudes of the stars could be deduced by noting the time of each observation; the only objection to this method was that angles exceeding 10 minutes of arc could not be measured by the spider-line micrometer with sufficient accuracy, but this objection might be overcome by the use of two eyepieces. The investigation of the elements of refraction on the preceding plan would, however, involve a special apparatus; but a heliometer could be readily adapted for the purpose, the apex of the prism being placed at right angles to the line of section of the object-glass.

The President. If I followed clearly the description of M. Loewy's observations, the essential point seems to be that it is a purely differential instrument and therefore free from systematic errors; but I was not able to follow so clearly the account of Mr. Gill's modifications of it. Yet I have no doubt that any suggestions from a practical observer of Mr. Gill's experience will be very valuable.

The Astronomer Royal felt scarcely prepared to offer an opinion offhand on the instrument proposed. The success of such a device depended greatly on the degree of facility with which it could be used in practical work. The original principle of M. Loewy was very ingenious and a very pretty application of optics; but it was to be feared that the reductions would involve a great deal of labour. Another difficulty would be the choice of the pair of stars. The principle, however, was well worth trying. As regarded Mr. Gill's modification, the fact that only one quarter of the object-glass was available for each star was a serious matter. There was another point which was worth bearing in mind, viz. that there was a large element of uncertainty in the determination of refraction arising from the accidental errors due to the state of the atmosphere, &c., so that in order to get a proper determination of the coefficient of refraction, especially near the horizon, a large number of observations would be necessary. It was therefore a most important matter to be able to get a large number of observations with as little labour as possible.

A vote of thanks was passed to Mr. Gill for his paper.

Mr. Common read a paper "On the Nebulæ in the Pleiades." He said that the Brothers Henry, in the photographs they had obtained of the Pleiades, had photographed three nebulæ which they supposed no one had seen before. But on Feb. 8, 1880, he had observed a nebula near Merope with the 3-foot reflector. The note he made at the time was to this effect:—"There is a strong suspicion in my mind of more nebulæ here." There appeared indications of nebulous matter near Merope in the direction of Electra. The photographs of MM. Henry did not show any nebula at that particular spot, but they did show a continuation of the nebula from Electra towards Merope. It was very remarkable, with so many observers in different parts of the world, who had examined the Pleiades with the view of finding out something fresh in the group, that these photographs should have given the first intimation of the existence of some of these nebulæ. He thought that the reason why these nebulæ had not been seen was owing to the fact that the atmosphere was always brilliantly illuminated in the neighbourhood of bright stars, so that the presence of a bright star generally prevented the eye recognizing faint points of light near it, but the photographic plate was not dazzled, and its power of discovering a faint point of light was not at all impaired by the neighbourhood of a bright object.

Mr. Knobel. I think, as Mr. Common has brought this subject forward, I may say that I had fully intended bringing this photograph before the Society at the last meeting, but Mr. Common had taken it away. All I could do therefore was to publish in the 'Monthly Notices' the letter sent me by MM. Henry. Mr. Common remarked in his earlier observation that he found an extension of the nebula in the neighbourhood of Merope towards Electra; but the photograph of the Bros. Henry showed a nebula extending from Electra towards Merope, which is a very different thing. The photograph shows also a very much fainter nebula. I did not understand whether he meant to say that he had observed that nebula or not. It is very remarkable that the nebula in the neighbourhood of Maia has produced a much greater effect on the photograph than the nebula near Merope, which has been observed by a great many observers. It would appear from the photograph of the Bros. Henry that the nebula near Electra was also stronger in photographic power than the portion of the Merope nebula which Mr. Common saw recently in his three-feet telescope.

Mr. Ranyard could hardly follow Mr. Common's reasoning as to the light of the nebula being overpowered by the brightness of the light dispersed in the atmosphere. So far as he was aware, no photograph had as yet been taken showing any trace of this dispersed light. It seemed more probable that the reason why these nebulæ had not been seen by observers was that they shone with light of short wave-length which readily impressed itself on the sensitive plate, but could not well be seen with the eye. He had had a lens of uranium glass made, and also a cell containing esserine, in order to see the nebula about Maia if it should be shining with light in the H and K region, by degrading its light into the visible part of the spectrum; but he had not had a good opportunity for seeing the Pleiades since.

Mr. Waters. I think Mr. Ranyard's explanation is probably correct. The matter might be set at rest by the use of different kinds of photographic plates, such as chloride plates or plates like those Capt. Abney uses, sensitive to the red and ultra-red rays. It is possible that there are nebulæ which emit only rays at the extreme red end of the spectrum; these might be photographed in this way, though they cannot be seen by the eye.

Mr. Common said that faint nebulæ were rendered visible to the eye by their contrast with the dark sky, but in the present case they were in contrast with the illuminated part of the sky. Every one knew that when a bright star was coming into the field a ring of brightness preceded it.

Mr. Ranyard said that no one had ever photographed that.

Mr. Common replied that with a reflector it was easy enough to photograph the light around stars. The larger stars in his photograph of the nebula of Orion then hanging in the room were all represented by patches of light, and there were traces of the rays seen in the instrument corresponding to the supports of the flat. It was certainly very curious that the Bros. Henry, who had probably intended to photograph the Merope nebula, had succeeded in photographing three others which no one had seen except himself. He had seen one, but had recorded it only by chance. Had he known what would happen he would have examined the region far more carefully.

The President. We have the pleasure of seeing Lord Rayleigh here—perhaps he will tell us what he thinks in regard to the question raised by Mr. Ranyard and Mr. Waters as to the light of different wave-lengths.

Lord Rayleigh. I would rather be inclined to ask questions than to answer them. It would interest me very much to know what is the explanation of the large disks we see produced on the photographic plates by the brighter stars. I used to photograph in old days, but I am not accustomed to the gelatine plates which have recently superseded all others. As far as I have noticed the photographs, the edges of the star-disks are very fairly sharp. I have a vague idea that they are not due to light generally diffused and gradually falling away. They suggest a different explanation. As to the kind of light that comes to us from these nebulæ, it would be a difficult question to decide. It is quite possible that the nebulæ may be more rich in the photographic rays; but I should rather be inclined to look for an explanation, as Mr. Common has suggested, in the difference of the effect of the neighbourhood of more intense sources of light on the eye and on the photographic plate.

Capt. Noble remarked that every practical observer knew that the visibility of stars depended much upon their colour. A red star of the eleventh magnitude was lost before a blue star of the same magnitude. It would seem probable that nebulæ differed in colour, and it might be that it was the colour of nebulæ which affected their visibility in photographs.

A Fellow called the attention of the Society to a letter by M. Wolf, which had recently appeared in the 'Comptes Rendus,' on this point. M. Wolf had pointed out that changes in the process, in the preparation of the plate, in the mode of development, resulted in changes in the photograph, and that therefore for photographs to be strictly comparable they must be taken in precisely the same way and under precisely the same conditions. Caution was needed, therefore, before accepting the fact that an object seen by the eye but not photographed was due to change. M. Wolf had further pointed out that in these very photographs of the Pleiades there were certain stars and nebulous phenomena absent which he (M. Wolf) had seen, and which had been verified by M. Rayet, of Bordeaux.

Mr. Waters. The apparent magnitudes of stars in a photograph are in many cases entirely disproportionate to the actual magnitudes as seen by the telescope and by the eye. The same may be the case with the nebulæ. The nebulæ may not be visible to the eye, and yet may be photographed possibly with great ease, owing to the greater actinic power of the light emitted.

Dr. Spitta thought the diffused light seen round stars was due rather to the instrument than to the diffusion of light in the atmosphere. He always fancied the field in an achromatic was much darker than in a reflector. The Bros. Henry used an achromatic telescope for their photographs. He had seen the *equatoreal coudé* in Paris, and had remarked how circular the star-disks were, and how dark the field. On his return home he had been struck with the amount of diffused light round the stars and in the field in his reflector.

Mr. Newall had repeatedly observed the Pleiades, and had noticed a considerable amount of nebulous matter round Maia, apparently throughout the entire group. He had constantly seen a beautiful oval light round Merope, which was said to be variable, but he believed the variation was entirely due to the state of the atmosphere. He had also seen a considerable amount of light round Maia.

Mr. Common pointed out that every photographer knew that by altering the exposure and development hard black pictures could be got which showed no half-tints; nothing was easier than to get such a picture, and it was no reflection upon the Bros. Henry that in their enlargements of their photographs they had reduced the stars to bright points or hard disks without any shade.

A vote of thanks was then passed to Mr. Common for his paper.

Mr. Turner read a paper on some observations for Coincidence of the Collimators through the centre of the Greenwich Transit-Circle. Originally this observation could only be made by raising the instrument. In 1866 the central cube of the transit-circle was perforated in such a manner that when the instrument was vertical a view of the S. collimator could be obtained from the N. collimator. It was then found that a small discrepancy existed between the readings through the cube and those taken when the instrument was raised. This discordance has, up to now, not been satisfactorily explained. To solve the difficulty a wooden model of the central cube of the transit-circle was made recently, and observations made with the instrument raised through this model cube were compared with observations through the ordinary cube. The readings came out:—

a.	Uninterrupted vision..........	0·465 rev.
b.	Through model cube	0·504 „
c.	Through ordinary central cube..	0·501 „

Thus the discrepancy appears to be due to a real difference between the lines of collimation of the central and excentric portions of the object-glasses, and suggests caution in the use of excentric pencils of light in observations of this kind.

The President. I would invite remarks on this paper upon what seemed to be an extraordinary discrepancy. I should not have expected that the wooden model would have the same effect as the cube of the instrument. It is satisfactory that the discrepancy is thus explained.

The Astronomer Royal. It is the usual habit of astronomers when they are in a difficulty about instrumental discordances to attribute them to temperature; I think Mr. Turner has shown that temperature has nothing to do with the present case and that it is purely an optical effect arising from the circumstance that a portion of the object-glass is used in one observation while the whole of the object-glass is used in the other. This paper, which is on a rather technical subject relating to the Greenwich transit-circle, has a much wider application than might be supposed at first sight, because it will apply to a great number of observations in which it is assumed when we use a certain portion of the object-glass in one observation and the whole of it in another that the observations are strictly comparable.

Lord Crawford. Has any careful observation been made of the object-glasses of the collimators?

The Astronomer Royal. I believe these object-glasses are very fair in figure, and, as far as I have been able to try them, they give very fair definition, but I do not think they have been tested thoroughly in star observations.

Lord Crawford. The collimators at Greenwich are exactly the same as the collimators of my transit-circle. I think mine are up to star work, and they are fair object-glasses of the first class.

Mr. Common. It would be very interesting if experiments were made with the upper half of the object-glass, while the lower half was shut out and *vice versâ*, and the readings taken with each.

The Astronomer Royal. I should say with regard to the question of definition of the object-glasses that it is a very large quantity we are dealing with; the discrepancy here is half a second of arc, so that it is not a quantity of the same order as any which could be due to faulty definition of the object-glass. Of course many further experiments might be tried in this direction, and I think Mr. Common's suggestion is a very good one.

Mr. Dunkin. The experiments described by Mr. Turner are very interesting. I should like to know whether, in the Cape Transit-circle (where there is no interference in the aperture), there is any difference between the readings of the collimators when the instrument is raised and when the wires of the collimators are viewed through the cube. I do not know whether that has ever been determined.

Mr. Turner. Mr. Finlay when he was over here informed me that nothing of the kind had been noticed. At Cambridge also there has been nothing of the kind noticed.

Lord Crawford. We have noticed nothing of the kind at Dun Echt with the six-inch telescope.

The President. Is there any other large transit instrument which has this same arrangement in which the orifice has these cross bars in it as at Greenwich, or is it quite unique?

Mr. Turner. I think it is quite unique. I have never heard of any other instrument.

Lord Crawford. I have seen a number of transit instruments, but never seen one resembling it.

The President. And I do not suppose it is likely any other will be made.

A vote of thanks was passed to Mr. Turner for his paper.

Mr. Knobel read a paper by *M. Trouvelot* on "The Protuberances Visible in the Spectrum with a Narrow Slit." The author referred to a paper on the subject read by Mr. Maunder at the last meeting of the Society, and noticed in the 'English Mechanic,' wherein Mr. Maunder was reported to have said that an observation recorded by M. Trouvelot was impossible, on the ground that protuberances of a certain height—say 3 minutes 37 seconds—could not be seen as a whole with the slit open, nor at all with a narrow slit. Such remarks from an experienced observer like Mr. Maunder had excited his surprise; because the first phenomenon was not so difficult to detect, and the second might be seen at least once or twice in a year. Protuberances projected on the spectrum might not have been seen by Mr. Maunder, as they were rare; but he (M. Trouvelot) could easily see protuberances three minutes in height with a wide open slit, when the sky was clear and the prominence tolerably bright. He used a tangential slit wide open which permitted a sight of the whole form at once. If Mr. Maunder covered his head with a dark cloth, and allowed his eye to become accustomed to the darkness, he would soon be able to see protuberances with a wide open slit, and probably ere long would see one projected on the spectrum. M. Trouvelot further described in detail an observation of this kind which he had made. With a narrow slit placed tangentially close to the Sun's limb he had seen a protuberance 2′ in height apparently projected on the spectrum on the side towards the violet. Moving the slit slowly away from the Sun, the protuberance seemed to be gradually covered up the further the slit was from the limb, until at length it disappeared entirely. The paper was accompanied by a movable diagram illustrating the observation and the mode in which the protuberance disappeared.

Mr. Maunder. It is rather a pity that M. Trouvelot wrote his answer without waiting to see my paper. He took his account of it from the report given in the 'English Mechanic,' which is very condensed, and unfortunately omits the very gist of the whole matter. My criticism of M. Trouvelot's earlier observation was based on this point, and this point alone, that his observation was not reconcilable with the theory that displacement of the lines of the prominence indicated motion in the line of sight, because so interpreted his observation would mean that the prominence was moving not only at the speed he mentions, namely, about 1600 miles per second, but with every conceivable variety of motion from rest up to that motion. We cannot conceive the same body as at one and the same time at rest and in rapid motion. Therefore I thought it was proof positive either that that theory must be modified, or that there was some error in the observation. The further information which M. Trouvelot has now sent, about another observation which he had described in the same paper as the one I criticised before, seems to make it more clear than it was before that the error lies in the observation. He describes a prominence, an upright jet, some two minutes in height, and says he saw it in its entirety with a narrow tangential slit placed close to the Sun's limb. It was projected on the spectrum on the side towards the violet. He then moved the slit away from the limb parallel to its first position, and as he moved it away the prominence gradually disappeared on the side nearer the red. It was not affected at all with regard to the part which was projected on the spectrum towards the violet. He moved his slit little by little in this manner until it was moved two minutes away from the Sun's limb, and then he saw just the very tip of the prominence. It is absolutely impossible that he could get any light into his spectroscope to form his spectrum, except what he got through the slit, unless, indeed, he had a transparent slit plate. The only way of accepting the account of the observation would be to suppose that whereas the side of the slit plate towards the red was opaque, the side towards the violet was transparent, at least for such light as the prominence emitted. The probability is that M. Trouvelot was not accurately informed either as to the width of the slit he was using, or as to the height of the prominence from the Sun's limb, so that whereas he thought he had a narrow slit, he really had a wide one; and whereas he thought he was observing a prominence two minutes in height, he was observing one very much smaller. If we make that supposition, the observation is intelligible, but I do no see any other way of explaining it. It is clearly impossible he could see prominences of this size through a narrow slit close to the Sun's limb, or that he could see light that was outside the slit and two minutes away from it. (Hear, hear!)

Mr. Ranyard. There is another remarkable point about these prominences. Since, with a narrow slit, the prominence was seen as two minutes away from the limb, the summit of the prominence was displaced from the C line eight times the distance between the D lines, which would mean that that part of the prominence was advancing towards us at the rate of 1500 miles per second—that is, it would be moving fastest at its summit, which would be very improbable.

Mr. Turner. I understand that the apparent summit is not really the highest point in the case of M. Trouvelot's prominence. The apparent summit is merely the light from the portion of the prominence moving most rapidly.

Mr. Ranyard. But M. Trouvelot calls it the summit. Of course no light could come to the slit from thence, two minutes away from the Sun's limb.

Capt. Noble. He did not merely open the slit, but moved it bodily away from the Sun.

Mr. Maunder. I have seen prominences projected in the spectrum, but it has been under very different circumstances to those M. Trouvelot describes. Such observations have frequently been made, and are recorded in all the text-books. With a radial slit, I have seen a prominence displaced bodily away from the C line. That is readily explainable; the entire prominence was moving towards us, or from us, at a certain definite speed. In this case, as the entire mass of gas was moving at the same speed, there is nothing self-contradictory in the observation; but an observation like that M. Trouvelot has given is self-contradictory, as he observed his prominence as in rest and in rapid motion at the same time.

Col. Tupman. His observation implies that he saw the shape of the prominence through one of the plates of the slit of his instrument; *i. e.* he saw it through a piece of solid brass.

Lord Crawford. I think it is common to see prominences on the spectrum, but without being able to trace them up to the limb of the Sun. There is hardly a day when it cannot be seen if fairly good dispersion be used. Using a radial slit you may come up to a prominence, and may perhaps trace it a long way from the Sun's limb; whilst a little further on it will suddenly come running down into the limb.

Mr. Maunder. That is not what M. Trouvelot describes.

Lord Crawford. The observation, as described by M. Trouvelot, is evidently impossible; but I have often seen, with a narrow slit, the displacement of a bright prominence line which looked like a prominence form projected on the spectrum, especially with a floating cloud or detached portion of a prominence.

The President. With regard to M. Trouvelot's observations, I am sure the Society is pleased to have this further explanation of what he observed, and that you will return the thanks of the Society to him.

Col. Tupman read a paper by *Mr. Baden Powell* on the orbit of α Centauri, showing that a period of about 87 years would satisfy the recorded equatoreal measures.

Also a paper by *Mr. W. H. Finlay* on the magnitude of η Argûs in March 1886, giving the determination as 7·6.

The following papers were also announced :—

W. F. Denning. "Note on the Radiation of Meteors."

Adelaide Observatory. "Observations of the Phenomena of Jupiter's Satellites made with the 8½-inch Cooke Equatoreal in the year 1885."

Radcliffe Observatory, Oxford. "Observations of Occultations of Stars by the Moon 1884–85, and of Eclipses of the IVth Satellite of Jupiter 1885."

W. G. Thackeray. "On the Semi-diameter of Venus."

Royal Observatory, Greenwich. "Observations of Comet *d* (Fabry) and *e* (Barnard)."

W. H. S. Monck, 13 Belvedere Place, Dublin, was duly elected a Fellow of the Society.

The Meeting adjourned at 10 P.M.

Liverpool Astronomical Society.

The seventh meeting of the Session was held on Tuesday, April 13, in the Association Hall. Mr. Isaac Roberts, F.R.A.S., President, in the Chair.

The President exhibited some of Messrs. Henry, Bros.', stellar photographs of parts of Cygnus; also a highly magnified Sun-spot taken at Stonyhurst (scale Sun's diam. = 0·6 metre); also two negatives taken by himself, one of the Pleiades with 15^m exposure, and the other of the nebula in Orion with 37^m exposure, showing a great deal of detail and many stars. Both had been taken with his silver mirror of 20 in. aperture and 100 in. focus.

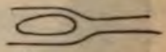
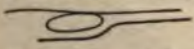
A paper sent by Mr. J. E. Gore, "On some suspected Variable Stars," was read; likewise one on Photometry by Mr. W. H. Sharp. Mr. Sharp's paper gave rise to considerable discussion, its main principle being in the arrangement of mirrors or prisms in front of the object-glass, so that stars should be, so far as the instrument is concerned, compared under identical conditions.

The Rev. S. L. Brakey, M.A., was elected a member of the Society.

The second session of the educational branch was closed on April 21 by a lecture on spectrum analysis, by Mr. James Gill, of the Sailors' Home. Borrowing an illustration from sound-waves, the lecturer described how the waves of light could actually be measured, and the nature of their propagation ascertained by simple arithmetical formulæ. The difference between the approach and recession of an express train altered the musical pitch of its whistle very appreciably, and the same phenomenon happened with light-waves. By the spectroscope they not only recognized the different elements which were present in distant stars and nebulæ, but, by a shifting of the position of the hydrogen line either to the red or violet end of the spectrum, they were enabled to ascertain at what speed a distant luminous object approached or receded from us in of the spot and belt on March 21 and 23, and, in addition to what has been already quoted in the 'Observatory' for April, p. 165, says:—"The red spot passes to a fine point on its *p.* end, and this is connected with a narrow grey piece of belt which precedes it. The *f.* end rather blunted and darker than that *p.* The elliptic character of the spot very evident from the light interior."

Mr. K. J. Tarrant (10-in. reflector, p. 280) writes:—"On March 31 at 8^h, the red spot was on the meridian, and the S. *f.* edge was undoubtedly extended to the dark belt above it, and appeared to me to overlap it as though on this side of it. The interior of the spot was much fainter, almost white, and at the S. *p.* edge was drawn out into a faint streak that extended almost up to the limb. There is not the slightest doubt about the connection between the red spot and the faint S. belt." On April 6 Mr. Tarrant reobserved the spot, and says:—"its red colour was much deeper at the S. *f.* edge, and at the place of junction with the belt the colour appeared grey and in streaks. The white central line in the spot was very plain, and the whole interior part was much paler than the margin. The little dark speck at the *f.* end of the spot was well seen."

Mr. J. Gledhill (9⅓-in. refractor, p. 240) examined the red spot as it was nearing the central meridian at 10^h on April 9. He says:—"The red spot is fast becoming very much like the ellipse I saw in 1869–70, *i. e.* a mere outline. The lower edge is thinner than the upper; from a little above the *p.* end there runs a narrow band straight on to the W. limb. The broad faint band above the spot is in contact with the upper edge of the spot."

Mr. G. T. Davis (3¾-in. refractor) writes:—"On March 9 there seemed a brighter zone above the red spot so:— 
On March 21 the spot appeared to touch the darker S. zone, so:—
 On March 31 the dark streak S. certainly seemed to run into the spot. These are the only occasions I have recently observed it, but it is not easy with my aperture at any time."

The Rev. J. J. M. Perry (18¼-in. reflector, p. 150) writes that on April 9 he had an opportunity of examining the red spot. "A gale of wind had been blowing all day, and the definition was atrocious, but I could distinctly see the red spot and trace its shape all round its circumference. Its colour was very pale red. There was a large streak or belt immediately S. and S. *f.* of a pale leaden blue, and the S. *f.* side of the red spot was distinctly projected * upon this belt."

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* Mr. Tarrant's results and my own at Bristol confirm this view that the red spot *overlaps* the belt, and is therefore higher in the Jovian atmosphere. It also agrees with my theory that the swifter spots are much nearer the actual surface of the planet than those which, like the red spot, form the slower-moving class.

Messrs. Franks (11¼-in. reflector), Elger (8½-in. reflector), and Backhouse (4¼-in. refractor) have also noticed the junction of the spot and outlying S. belts.

I think there can be no doubt whatever that the two markings are not physically associated; they are probably at different heights in the Jovian atmosphere. The red spot is still a compact ellipse showing no signs of breaking up. That it coincides with a belt on its S. side is a mere result of different relative motions in objects situated in nearly the same parallel of latitude. The dark connecting belt is moving quicker than the red spot, though not much so. The latter will soon clear itself as in 1884 and 1885, and we shall see it again with a white aureola fringing its environs.

The configuration of the markings on this planet are to a great extent recurrent. When we have ascertained the difference of rotation periods in two objects we may readily find the cycles when they become presented in the same places relatively to each other. In this particular case of the junction of the red spot and S. belt the phenomenon will recur on about May 23, 1888, the cycle being about 790 days. On Jan. 27, 1884, I saw the region of the red spot just as I saw it on Mar. 23, 1886. The interval amounts to 786 days. On Dec. 7, 1881, I drew a broad faint belt ('Nature,' Jan. 5, 1882) coming very close up to the S. *f.* side of the red spot, and extending also from its S. *p.* side. The spot evidently overlapped this belt. There was also a very dark variegated belt on the S. limits of the spot, which was well delineated by Prof. Hough on Dec. 1 and 28 (Report of Dearborn Observatory, 1882), and his sketches are also valuable as proving the slightly quicker motion of the belt relatively to the spot. Between my observations of Dec. 7, 1881, and Jan. 27, 1884, we have an interval of 781 days. On Sept. 25, 1879, Mons. L. Niesten saw the red spot involved with the S. belts. Here we have an interval of 804 days to Dec. 7, 1881. The mean of the three periods (786, 781, and 804 days) is 790 days. The faint belts S. of the red spot must therefore rotate in 18·71 sec. less time than the red spot, so that they gain 45·24 sec. per day, and $9^{h}\ 55^{m}\ 39^{s}{\cdot}6$ *, or one revolution, in 790 days.

Another test may be applied in confirmation of the fact. In the 'Observatory' for March 1881, p. 83, I give the rotation of a dusky streak or short belt S. *p.* the red spot as 17½ sec. less than the red spot. For a similar object Mr. Barnard found a period of $9^{h}\ 55^{m}\ 16^{s}$. In the 'Monthly Notices,' Dec. 1883, p. 72, I give the time for a S. belt $9^{h}\ 55^{m}\ 17^{s}{\cdot}9$, and that of the red spot $9^{h}\ 55^{m}\ 36^{s}{\cdot}2$, or 18·3 sec. greater. This difference of velocities is almost identical with that of 18·7 sec. rendered necessary by the adoption of 790 days as the period of recurrent positions. The very slight difference may well have been induced by the variable rates of motion which it is well known affect the markings and render the accurate prediction of their relative places at a future time a matter of great difficulty.

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* Prof. Hough finds the mean rotation period of the red spot from Sept. 25, 1879, to June 29, 1885, comprising 2104 days, or 5086 rotations, is $9^{h}\ 55^{m}\ 37^{s}{\cdot}4$ (Report of Dearborn Observatory, 1885, p. 13).

While speaking of recurrences, I may note that there is a brilliant spot breaking the continuity of the N. side of the great N. belt which in the interval of 434 days from Jan. 27, 1885, to April 6, 1886, has gained by its greater velocity $2^h\ 29^m$ ($=90°$) upon the red spot. Its cycle relatively to the red spot is therefore a long one of 1736 days or $4\frac{3}{4}$ years. As to the white and dark equatoreal spots ranging along the N. side of the great S. belt, they move very much swifter. I have watched the chief white spot *, a very durable though variable feature, for $5\frac{1}{2}$ years. Comparative observations on 1880, Nov. 19, and 1886, April 9, show that in the interval of 1967 days 10 hrs. 7 min. between the two conjunctions of 1880, Nov. 19, $9^h\ 23^m$, and 1886, April 9, $19^h\ 30^m$, this white spot completed no less than 44 revolutions of Jupiter relatively to the red spot, so that its cycle is $44^d\ 17^h\ 8^m$. There are many other interesting deductions to be made respecting the motions and varying forms of the markings on this noble planet. It will be found that many of these markings though affected by great changes of appearance and differences of velocity, are yet very durable, and probably existed long before the telescope first intimated their existence. W. F. DENNING.

Bristol, 1886, April 15.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Discovery of the Great Nebula in Andromeda.

GENTLEMEN,—

In my letter to you of the 10th of March (published in your number for the present month) I referred to Halley's error (reservedly expressed with the words "if I mistake not") in attributing ('Phil. Trans.' for 1716) the discovery of the great nebula in Andromeda to the French astronomer Bullialdus about the year 1661. I should be glad now if you could spare me a small portion of your valuable space to point out that Boulliau himself was perfectly aware of the earlier observation of Simon Marius. His tract 'Ismaelis Bullialdi ad Astronomos Monita Duo,' published at Paris in 1667, is, I believe, very rare, at any rate in this country, which will perhaps render this reference to the second part or 'Monitum' (the first is on the star Mira or *o* Ceti) of that work interesting to some of your readers. It is headed "De Nebulosa stella, in Cingulo Andromedæ anno 1665 ineunte deprehensa." Boulliau states that the nebula was noticed by several persons (some of whom thought it to be another comet) about the beginning of that year, in consequence of the attention attracted to the sky by the comet which appeared towards the end of 1664, leading astronomers to examine closely the region of the heavens through which it passed. He quotes the previous observation of Simon Marius, as given in the Preface to his 'Mundus Jovialis;' and as that work is also somewhat rare, it may be interesting to reproduce the whole passage from the original:—

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* This object comes to the central meridian $2\frac{1}{4}$ hours before the times given in Mr. Marth's Ephemerides ('Monthly Notices,' vol. xlv. pp. 509–13; and 'Companion to Observatory,' 1886, p. 34).

"*Quatuor alia nunc subjungam, de quibus in dedicationibus meis annuorum prognosticorum hactenus nullam feci mentionem. Inter illa primum est, quod medio ante perspicillo à die* 15 *Decemb. Anni* 1612. *invenerim et viderim fixam vel stellam quandam admirandæ figuræ, qualem in toto cælo deprehendere non possum. Ea autem est prope tertiam et borealiorem in cingulo Andromedæ. Absque instrumento cernitur ibidem quædam quasi nubecula: at cum instrumento nullæ videntur stellæ distinctæ, ut in nebulosa cancri et aliis stellis nebulosis, sed saltem radii albicantes, qui quo propriores sunt centro eò clariores evadunt, in centro est lumen obtusum et pallidum, in diametro quartam fere gradus partem occupat. Similis fere splendor apparet si à longinquo candela ardens per cornu pellucidum de nocte cernatur; non absimilis esse videtur Cometæ illi, quem Tycho Brahe Anno* 1586 *observavit. Mense Septembri Anni superioris**, *quando mecum erat Doctissimus vir M. Lucas Brunnius Illustrissimi Electoris Saxonici Mathematicus, inter alia tunc Mathematica colloquia, quia se offerebat grata serenitas, etiam hanc ipsi stellam monstrosam commonstravi, quam summa cum admiratione vidit. An autem nova sit necne, certo asseverare nequeo, dispiciant et judicent id alii. De oculatissimo Domine Tychone miror, qui borealiori fixæ in cingulo Andromedæ, instrumentis suis locum secundum longum et latum præfinivit, hanc tamen nebulosam intactam reliquit, quæ tamen proxima est illi.*"

Boulliau, however, thinks it easy to account for the fact that the nebula was not seen by Tycho and others (amongst whom he thinks, in all probability, Hipparchus may be included—the catalogue of Sûfi was of course not known to him), viz., by regarding its brightness as variable, like that of Mira Ceti; indeed, he asserts that its light when he was writing, in the month of November 1666, was much feebler than it had been early in the previous year. And he gives a figure of Andromeda from some old parchment charts of the constellations, which had been brought from Batavia (*i. e.* the part of Belgium formerly so called) by Thouanus (*i. e.* the famous statesman and historian, Jacques Auguste de Thou); in this two fishes are marked covering the breast of Andromeda, and a little beyond the mouth of the foremost fish (where the great nebula would be) is placed a number of dots evidently meant to indicate a nebulous appearance, as Præsepe is marked in the same way in the drawing of Cancer. It is mentioned in the letterpress (by some anonymous author) accompanying these charts that it was written in 1428, but the date of the charts themselves is stated to have been much earlier, thought by some to have been in the time of King Alfonso, though probably there were later additions. Numbers were affixed, too, to the stars for the purpose of distinguishing them, some time after the letterpress was written; but from the style of the figures of these numbers, Boulliau thinks it almost certain that they were marked in about the year 1500. The dots indicating the nebula were probably inserted at the same time; hence Boulliau concludes that it was noticed by some anonymous observer about 150 years before his own time. This last fact is referred to by Smyth in the 'Celestial Cycle;' but the whole of the circumstances under which the conclusion is drawn will, it seems to me, be of interest to those of your readers who have not ready access to the tracts of Marius and Bullialdus. Of that, however, you will be the best judges.

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* Marius means by this the year 1613, his treatise having been published in 1614.

Yours faithfully,

Blackheath, 1886, April 6. W. T. Lynn.

Photography and the Pleiades.

Gentlemen,—

From what was said during the discussion which followed the reading of Mr. Common's paper at the last meeting of the Royal Astronomical Society, and from what can be learnt through the published observations of M. Tempel and other astronomers, who have made this cluster and the Merope nebula their special study, it would appear as within the limits of probability that the stars in this group are projected upon a nebulous background, of which the Merope nebula and that near Maia photographed by the Brothers Henry are but the brighter portions. I would therefore like to point out the advisability of using photographic plates, so prepared as to be capable of rendering the infra-red and the ultra-violet rays visible. To those astronomers possessing the requisite optical means, there is a wide field of research open in this direction; and even if the results in this particular instance were of a negative nature, such photographs would probably throw unexpected light upon points now undreamt of.

Forest Gate, E. Yours faithfully,

B. J. Hopkins.

The Variable Star η Argûs.

Gentlemen,—

Immediately on receiving the February number of the 'Observatory' last evening, containing Mr. Lynn's interesting letter on η Argûs, I turned the telescope on the star and compared it with neighbouring stars in the Catalogue on page 42 of Sir J. Herschel's 'Cape Observations.' I estimated it to be equal or perhaps a shade superior to F 630, slightly superior to K′ 452, much superior to C 468, D′ 571, and D 575, and equal or perhaps slightly inferior to the combined light of O 403, 404. From these comparisons it appears that the variable does not exceed the seventh magnitude. Mr. Lynn correctly remarks that my latest published comparisons are contained in the R. A. S. 'Monthly Notices,' Vol. xxxvii. p. 280. Since the close of 1876 I have obtained comparisons on the following dates, the results of which I intend shortly to publish:—1877, March 14, 20, April 6, May 5, Sept. 12, Dec. 11; 1878, March 4, 20, May 11, June 28, August 30, Dec. 18; 1879, March 10, May 22; 1880, Jan. 21, March 22, May 3, 5, June 9, July 12, Aug. 22, Oct. 29, Dec. 1; 1881, Jan. 27, June 1, Aug. 19, Dec. 21; 1883, Dec. 18; 1885, May 4; 1886, March 17. In the meantime I may, however, remark that although the star's light has exhibited very slight fluctuations, it certainly did not on any of these dates exceed the seventh magnitude. My comparisons since 1881 have unfortunately been very few, but I may add that during this period my attention has been frequently directed to R Carinæ, the highly interesting variable in the immediate neighbourhood of η Argûs, so that I think the latter could hardly have been of the fourth magnitude without my detecting the change. R Carinæ has recently passed its maximum, 4·6 mag., which nearly equals that which it had at the maximum of December 1880.

Yours faithfully,
JOHN TEBBUTT.

Windsor, N. S. Wales.
1886, March 18.

GENTLEMEN,—

With reference to Mr. Lynn's letter regarding this variable star, in the 'Observatory' for February (p. 101), between November 1885 and March 1886 I frequently examined the neighbourhood of the star with an opera-glass, but without being able to see any signs of it. On one night, Nov. 21st, 1885, a faint stellar point was seen about in the right position, the magnitude of which was estimated at 5·7; but this was very probably one of the other faint stars surrounding the variable, perhaps L. 4479 and L. 4484 seen together. The nebula was also examined several times in February last with a 2¾-in. refractor; and though η was not identified, I do not think there were any stars near so bright as the 6th mag.

It would seem from this that η Argûs, up to last March, was still invisible to the naked eye, and very far from being so bright as the 4th magnitude. The latest observation recorded in Gould's 'Uranometria Argentina' was made in November 1878, η being then about 7·4 mag.

Yours faithfully,
A. STANLEY WILLIAMS.

West Brighton,
1886, April 26.

NOTES.

THE ZODIACAL LIGHT.—We gave in the 'Observatory,' Vol. vii. p. 265, a notice of a valuable paper by Prof. A. Searle on the Zodiacal Light. Prof. Searle has since continued his investigations, and in a recent memoir has discussed Jones's observations of the "Stronger Light," correcting them for the effect of atmospheric absorption. It will be remembered that one of the principal conclusions arrived at in Prof. Searle's earlier memoir was that the apparent position of the zodiacal light was largely affected by atmospheric absorption. The present investigation has confirmed that conclusion, and has led to the following additional inferences:—

(1) "After allowance for the effect of absorption, there is reason to think that the zodiacal light, as seen during the second half of the nineteenth century, has had a more northern latitude near the longitude 180° than near the longitude 0°.

(2) "Upon the meteoric theory of the zodiacal light, it is to be expected that a continuous zodiacal band should be present; but the question of its actual visibility is complicated by the slight maxima of stellar density, which are situated along those parts of the ecliptic most readily accessible to observation from stations in the northern hemisphere."

(3) "The belt of sky occupied by the projections of the orbits of the first 237 asteroids presents certain peculiarities which correspond to those of the zodiacal light, and suggest the hypothesis that the light may be partly due to minute objects circulating in orbits like those of the smaller planets."

Prof. Geelmuyden, in the 'Amer. Journ. of Science' for April, remarks on the above conclusion that, supposing the zodiacal light to bear the same relation to the general meteoric matter of the solar system which the short-period comets have to comets in general, there should be some relation between the plane of the orbit of Jupiter and that of the zodiacal light, and he remarks that such a coincidence actually exists, for "the most northerly point of Jupiter's orbit has the heliocentric longitude 188°, or with 60° east elongation 178°; and for matter in the same plane, but nearer the Sun, the approximation to coincidence with 160° is still greater."

RELATION OF ASTEROID ORBITS TO THAT OF JUPITER.—In a note in the same number of the 'American Journal,' Prof. Newton points out the interesting fact that, if a mean orbit be found for the 251 asteroids first discovered, equal weight being given to each, the orbit of Jupiter lies nearer to that mean orbit, being inclined to it only 30′, than any single asteroid orbit does, the nearest orbit being that of Medusa, inclined to it at an angle of 46′. Euterpe is the only asteroid whose orbit is inclined to that of Jupiter at a less angle than 30′, its inclination being 19′ to that of Jupiter, and 49′ to the mean orbit of all the asteroids.

NUTATION FORMULÆ*.—M. P. Ubaghs of Liège has recently worked out the formulæ for annual nutation and precession on the lines indicated by M. Folie in his paper "Théorie des mouvements diurne, annuel et séculaire de l'axe du monde" †. In this computation account has been taken of the terms containing the eccentricities of the terrestrial and lunar orbits, as well as the inclination of the latter to the plane of the ecliptic, to the fourth order inclusive; so that it has been necessary to take into account the principal periodical inequalities of the Moon's longitude, viz. the annual equation, the evection and variation to terms of the same order. M. Ubaghs has, however, neglected the effect of the attraction of the planets, of the figure of the Earth, of the inequalities of the apparent motion of the Sun round the Earth, as well as secular inequalities in general. Following M. Folie, the nutation formulæ have been given in terms of the *mean* longitudes of both Sun and Moon; this writer having expressed the opinion (in the paper referred to above) that the formulæ containing the mean longitudes are much more simple to calculate than those which are expressed in terms of the true longitudes of the Sun and Moon, and, moreover, do not contain any term depending on the Solar perigee, nor (unless account be taken of terms depending on the figure of the Earth) on the Lunar perigee. It will be remembered that Peters, in his classical work 'Numerus Constans Nutationis," transformed the mean longitude of the Sun into true longitude in his final formulæ, whilst retaining the mean longitude of the Moon. This transformation should theoretically have introduced terms depending on $\cos 2\Gamma$ and $\sin 2\Gamma$ (where Γ is the mean longitude of the Sun's perigee), but the coefficients are extremely small, and Peters has neglected them. In this connection also M. Folie has pointed out the remarkable circumstance, that in the nutation formulæ, terms with arguments ☾ $+\Gamma'$ and ☉ $+\Gamma$ have respectively coefficients very nearly equal in magnitude, *but of contrary signs*, according as we make use of mean longitudes or true longitudes. He also finds that the signification of the constant of nutation is not the same in the one case as in the other. We cannot therefore, M. Folie concludes, substitute true for mean longitudes in these formulæ without the introduction of error. It appears doubtful, however, whether the errors thus introduced would be appreciable in the present state of the art of astronomical observation.

Having effected the numerical calculation of the coefficients of the different terms, by the adoption of values of the constants which occur in them, M. Ubaghs compares his results with those of Peters and Nyrén, and for this purpose transforms the mean longitude of the Sun into true longitude. The following are the more noteworthy discordances in the coefficients, all occurring in the expression for $\Delta\psi$:—

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[*] Mémoires de l'Académie Royale de Belgique, tome xlvii.

[†] Ibid. tome xlv.

Peters.	Nyrén.	Ubaghs.	Term.
−0·2041	−0·2046	−0·2181	Sin 2☾
+0·0053	+0·0054	−0·0054	Sin (2⊙ − 2Γ′)
+0·0057	+0·0057	−0·0054	Sin (☾ − Γ′ − ☊)
+0·0125	+0·0125	+0·0043	Sin (2⊙ − ☋)
+0·0150	+0·0143	−0·0004	Sin (☾ − 2⊙ + Γ′)
−1·2694	−1·2588	−1·2273	Sin 2⊙

A French Edition of Oppolzer's Treatise on Orbits.—Prof. Oppolzer's Treatise on the determination of the orbits of Comets and of Planets is so well known as the most exhaustive work of its kind hitherto published, and one which forms a sort of connecting-link between the labours of the mathematician and those of the practical astronomer, that the appearance of a French translation of the book will be gladly welcomed by those who do not read German with ease, and to whom therefore the study of Prof. Oppolzer's work in the original was a formidable undertaking. The French Edition, of which the first volume is now published, is a translation of the Second German Edition, undertaken by Prof. Ernest Pasquier of Louvain with the full approval of the author, and with his cooperation, as well as with that of Dr. Schram, who so efficiently assisted Prof. Oppolzer in the publication both of the first and second volumes of the German Edition. M. Pasquier has spared no pains in order to make this new edition a trustworthy guide both to the student and to the practical astronomer; thus he informs us that the numerical tables appended to the volume have been revised three times whilst the work was passing through the press, and that they are now, in his opinion, quite free from errors. The importance of this to any one making practical use of the tables can hardly be overestimated. The translator, in concert with the author, has made a few modifications in the work, so that it is not altogether a mere reproduction of Prof. Oppolzer's Treatise. The most important of these is the introduction, in accordance with the recommendations of the Washington International Meridian Conference of 1884, of the mode of counting time and longitude proposed by the conference. We regret that this course should have been taken, as it will tend to deprive the book of much of its cosmopolitan character, and limit its usefulness as a text-book to those places in which the proposed change may be adopted. After all, however, the introduction of this modification may not be without its advantage, as M. Pasquier has considered it advisable to indicate the corrections which it is necessary to apply to the text and to the tables should one wish to continue to reckon the astronomical day from mean noon of each place, instead of using universal time. A glance at these corrections will show astronomers something of the troubles that are in store for them should they make the change which the Washington Conference has recommended.

M. Pasquier's work is published in Paris by M. Gauthier-Villars, and in excellence of paper and clearness of type fully maintains the reputation of that celebrated establishment. We hope before long to be able to announce the publication of M. Pasquier's translation of the second volume of this important treatise.

ASTRONOMICAL DIRECTORY.—A very useful pamphlet has recently been published by M. Lancaster, of the Brussels Observatory, containing a general list of Astronomical Observatories throughout the World, with their geographical coordinates and the astronomers attached to each. This list is supplemented by others dealing with the Societies and Institutions connected with astronomy, as well as by a short account of Reviews and Periodicals specially devoted to the science. There is a further section giving the names and addresses of astronomers not attached to any observatory, of amateurs whose names do not appear in the first list, and of makers of astronomical instruments. M. Lancaster has also supplied a general alphabetical table, containing the names of the persons mentioned in the body of the work, with a reference to the page on which each name occurs. It is evident that such an astronomical directory, if exhaustive and accurate, would be a great boon to astronomers, and M. Lancaster's little book comes sufficiently near this description to make it of the greatest service to workers in our science. It would greatly increase the value of the work if the principal instruments at each observatory were given, as well as the line of research on which they are engaged. Perhaps, in a second edition, the author will be able to give these additional details. Probably the bulk of the *errata* in the present edition will be found in the list devoted to "unattached" astronomers. Thus, to take one opening of the book, we notice that the Indian addresses of Gen. Tennant and Gen. Walker, both of whom have now been residing in England for some years, are given. The name of C. E. Burton, who died in 1882, also appears in this list. And, perhaps most remarkable of all, the firm of Troughton and Simms does *not* appear amongst the names of makers of astronomical instruments.

THE BINARY STAR 70 OPHIUCHI [*].—Herr Schur, having noticed that there are now considerable differences between the observed position-angles and distances of this binary and the places computed from his orbit, proposes to undertake the investigation of corrections to the elements previously calculated by him. It appears, however, that the present is not a favourable time for a new determination of the orbit, as the two stars are now within 1″, and during the years 1886–1890 the position-angle will alter 70° to 80°. Herr Schur has therefore determined to wait some years before working up the materials which he has collected, and in the

[*] Astr. Nach. No. 2719.

mean time wishes to point out to those astronomers who have been in the habit of observing this object the importance of carefully carrying on their observations.

THE U.S. NAVAL OBSERVATORY *.—The Secretary of the Navy having asked the advice of the American National Academy of Sciences as to the advisability of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880, the Committee appointed to consider the question unanimously reported as follows:—

(1) It is advisable to proceed promptly with the erection of a new Observatory upon the site purchased in 1880 for this purpose.

(2) It is advisable that the observatory so erected shall be, and shall be styled, as the present observatory was styled originally, the National Observatory of the United States, and that it shall be under civilian administration.

(3) It is advisable that the instruments in the present observatory, with the exception of the 26-inch telescope, the transit-circle, and the prime vertical transit, shall be transferred to the observatory at Annapolis, with such members of the astronomical staff as may be required to operate them; also that such books of the library as relate chiefly to navigation shall take the same destination; the instruments above particularly specified, with the remainder of the library, being reserved as part of the equipment of the new National Observatory, to which also the remaining officers of the astronomical staff shall be assigned for duty.

(4) It is advisable that the Observatory at Annapolis should be enlarged, if necessary, and adapted to subserve as effectually as possible the wants of the naval service, whether practical, scientific, or educational; that it shall be under the direction of the Department of the Navy, and shall be styled the Naval Observatory of the United States.

THE PROPOSED CHANGE IN THE ASTRONOMICAL DAY *.—In response to a request from the Secretary of the Navy for advice on the point, the appropriate Committee of the American National Academy of Sciences recommends that a change in the beginning of the astronomical day, in accordance with the proposal of the Washington International Meridian Conference of 1884, be made as soon as sufficient concert of action can be secured among leading astronomers and astronomical establishments of the civilized world, in 1890 if practicable; if not, in 1900.

Writing with reference to this Report, Prof. Asaph Hall points out † that it is a mistake to assume that the Reports made by Committees of the National Academy of Sciences have been ex-

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* 'The Sidereal Messenger,' April 1886.

† 'Science,' Vol. vii. p. 286.

amined and approved by the Academy at large, and therefore that they express the opinion of that body. On the contrary, a report must be understood to represent only the views of the committee who sign it. It is Prof. Hall's opinion that a majority of the astronomers of the Academy would probably oppose such a change if they were permitted to speak. It would be interesting to learn who were the members of the Committee who signed this Report.

In a recently published paper [*], containing an account of the proceedings at the Washington Conference, M. Raoul Gautier expresses himself as decidedly averse to the proposed change, as far as the commencement of the astronomical day is concerned. He points out that the project has been opposed, from the first, by Profs. Förster and Newcomb, the superintendents respectively of the Berlin 'Jahrbuch' and of the American 'Ephemeris.' As to France, he thinks it is tolerably certain that the 'Connaissance des Temps' will not be in a hurry to conform to the recommendations of the Washington Conference. The superintendent of the English 'Nautical Almanac' not having expressed an opinion, M. Gautier does not know what course he will take; in any case his decision, whatever it may be, will exercise a great influence on the ultimate adoption or rejection of the scheme.

THE MAIA NEBULA.—In the 'Astronomische Nachrichten,' No. 2719, M. Otto Struve has published some interesting observations of this nebula and the stars in its immediate neighbourhood, *i. e.* an area of about 5 or 6 minutes in R.A. and Dec., as embraced in the Paris photograph. He remarks that, knowing what to look for, the nebula was readily detected with the 30-inch refractor, but could easily be missed in a single search. The Paris photograph shows two stars N. of Maia, one in the S.E., and two fainter stars, one to the E. and the other to the W. of Maia. According to Struve's observation on Feb. 23, the nebula showed distinctly from Maia to the star towards the E., and to about midway between Maia and the star in S.E., while faint traces could be seen almost to the latter. The brighter portion tapered towards the star immediately N. of Maia. This extremity was sharply defined, while a detached portion of nebulous matter was seen halfway between this point and the star. Five other stars, not shown in the Paris photograph, were detected. The star eastward of Maia is involved in the nebula and is apparently variable, for on the photograph, and also by Struve's observation on Feb. 5, it was about equal in brightness to the star westward of Maia, while on Feb. 23 it was almost two magnitudes fainter. On Feb. 24 the nebula was observed with the 15-inch, and fresh evidence was afforded of the star's variability. On March 3, Struve succeeded in tracing the nebula on each side of the S.E. star, and also detected two faint stars on the border of the nebula. No further evidence of the star's variability; but one of the stars detected on Feb. 23 was suspected to have varied.

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[*] 'Archives des Sciences Physiques et Naturelles,' Tome xv. No. 3.

THE RELIABILITY OF THE STAR-PLACES OF AUWERS' FUNDAMENTAL CATALOGUE[*].—Mr. Chandler having pointed out the possibility of error in the places of certain stars ('Observatory,' Vol. viii. p. 387) as given in the Berlin 'Jahrbuch,' Herr Auwers has been induced to publish some valuable and interesting remarks on the reliability of the places of his Fundamental Catalogue (Publication der Astron. Gesellschaft, xiv.), from which those given in the Berlin 'Jahrbuch' are derived. Herr Auwers explains the provisional character of the data on which some of his star-places depend, and repeats in a more definite manner what he has already said on the subject in Publication xiv. In fact the proper motions adopted for some of the fundamental stars are merely provisional, as has been pointed out in the introduction to the Catalogue. The proper motions employed have been, as a rule, obtained from a comparison of Bradley's places with those of Greenwich 1861 (a Catalogue of Bradley Stars compiled from Greenwich Observations 1836–1872, and reduced to the system of the First Seven Year Catalogue), and in those cases in which Bradley has only one observation, or observed the star in one element only, the proper motion is given to one decimal place less than usual. The reader is thus put on his guard, and knows that he should use the places of certain stars with circumspection. Herr Auwers thinks that it would be premature to attempt any correction of the catalogue-places before the completion of the general revision, which has been undertaken by the observers of the Zones and by the Pulkowa Astronomers. He, however, takes this opportunity of publishing the results of investigations he has made as to the mean errors of the different catalogues employed in the formation of the Fundamental Catalogue, viz.:—Pulkowa 1845 and 1865, Greenwich 1861 and 1872, Cambridge (U.S.) 1872, Leipzig 1868, and Leiden 1868, for the principal stars; and, in addition to these, Pulkowa 1871 for the supplementary stars.

The following are, in the mean (for Dec. −10° to +90°), the mean errors, referred to the unit of weight, for the principal stars:—

	P. 1845.	P. 1865.	G. 1861.	G. 1872.	C. 1872.	Lp. 1868.	L. 1868.
R.A. ($\epsilon \cos \delta$)...	$0^{s}{\cdot}040$	$0^{s}{\cdot}033$	$0^{s}{\cdot}038$	$0^{s}{\cdot}032$	$0^{s}{\cdot}031$	...	...
Dec. (ϵ).........	$0''{\cdot}51$	$0''{\cdot}61$	$0''{\cdot}55$	$0''{\cdot}52$	$0''{\cdot}86$	$0''{\cdot}46$	$0''{\cdot}58$

and for the supplementary stars:—

	P. 1845.	P. 1871.	G. 1861.	G. 1872.	C. 1872.	Lp. 1868.	L. 1868.
R.A. ($\epsilon \cos \delta$)...	$0^{s}{\cdot}043$	$0^{s}{\cdot}057$	$0^{s}{\cdot}053$	$0^{s}{\cdot}034$	$0^{s}{\cdot}035$	...	...
Dec. (ϵ).........	...	$0''{\cdot}72$	$0''{\cdot}64$	$0''{\cdot}52$	$0''{\cdot}89$	$0''{\cdot}72$	$0''{\cdot}52$

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[*] Astr. Nach. Nos. 2713–14.

We have then, finally, for mean error of the right ascensions $0^{s}\cdot033$ (for supplementary stars $0^{s}\cdot042$), and for the declinations $0''\cdot59$ (for supplementary stars $0''\cdot67$). The somewhat considerable difference in the results for principal and for supplementary stars arises from the circumstance that Herr Auwers gave relatively too much weight to Pulkowa 1871, at least for the right ascensions. For the catalogue-places, the mean errors are $0^{s}\cdot009$ and $0''\cdot14$ in R.A. and Dec. respectively for the principal stars, and $0^{s}\cdot026$ and $0''\cdot19$ for the supplementary stars, where the mean error in R.A. refers to the total number of stars between $-10°$ and $+50°$. At the present time, in Herr Auwers' opinion, the probable error of the star-places is not greater than $0^{s}\cdot02$ in R.A. (for moderate declinations) and $0''\cdot15$ in declination.

PHOTOGRAPH OF THE NORMAL SOLAR SPECTRUM.—Prof. Rowland has now completed his great photographic map of the Solar Spectrum from wave-length 3680 to 5790, and the portion above 3680 to the extremity of the ultra-violet, wave-length about 3100, is nearly ready. Negatives have also been prepared down to and including *B*, and it is possible they may be prepared for publication. These photographs have been made with one of Professor Rowland's concave gratings of 21½ ft. radius of curvature and 6 in. diameter, mounted so as to preserve the focus constant and give a normal spectrum of the same scale for any given spectrum. A scale of wave-lengths has been added, so that the whole makes a map of the spectrum, down to wave-length 5790, more exact and giving greater detail than any other map now in existence. The definition of the spectrum Prof. Rowland states to be more than equal in every part, down at least to wave-length 5325, to any map so far published. The 1474 line is widely double, as also b_3 and b_4, while *E* is given so nearly double as to be recognized as such by all persons familiar with spectrum observation. Above the green the superiority increases very quickly, so that at *H* we have 120 lines between *H* and *K*, while the original negatives show 150 lines. Above *H* to wave-length 3200, the number of lines in excess of all published maps is so great as to make all comparison useless.

The cost of the seven plates giving the complete spectrum from λ 3680 to λ 5790 is $10 unmounted, and $12 mounted on cloth.

PHOTOGRAPHIC STUDY OF STELLAR SPECTRA: HENRY DRAPER MEMORIAL.—Prof. E. C. Pickering states, in a circular from Harvard College Observatory, that Mrs. Henry Draper has made provision for continuing at the Observatory, as a memorial to her husband, those researches on the study of Stellar Spectra by means of photography to which Prof. Draper gave so much attention during his lifetime. The results already obtained with the aid of an appropriation from the Bache Fund, permit the form of the new investigation to be definitely stated. The part of the sky to be surveyed is that extending from the north pole to the parallel of thirty degrees south declination. Each photograph will be exposed for about one hour, and will include a region ten degrees square. The telescope employed has an aperture of 20 centim. (eight inches), and a focal length of 117 centim. (forty-four inches). The object-glass is covered by a prism, and the resulting spectrum of each star in the region photographed has a length of about one centimetre, which enables the character of the spectra of stars from the fifth to the eighth magnitude to be determined. A modification of the apparatus is employed for the brighter stars.

Meanwhile, experiments are in progress with the fifteen-inch equatoreal, with the object of representing the spectra of some typical stars upon a large scale. The spectra so far obtained are about six centim. in length, and exhibit much well-defined detail. Additional experiments will be tried with a spectroscope provided with a slit, as well as with the simple prism hitherto employed, in order to secure the best possible definition. The present results encourage the expectation that the movements of stars in the line of sight may be better determined by the photographic method than by direct observation.

To keep the astronomical public informed of the progress made in this work specimens of the photographs obtained will be gratuitously distributed from time to time to those who are interested in this class of work. The first of these distributions will probably be made in a few weeks.

PARALLAX OF NOVA ANDROMEDÆ *.—Prof. Asaph Hall has made a series of measures with a view to ascertaining if this star showed any appreciable parallax. The star used for comparison was the one preceding the Nova by about 2′ of arc. The measures, which were commenced 1885, Sept. 29, and continued until 1886, Feb. 7, gave no certain indication of any parallax. There was indeed a slight apparent diminution of the distance of the Nova from the comparison star; but the increasing difficulty of accurate measurement, as the Nova faded away, might fully account for the slight discrepancy. The Nova had faded down to the 16th mag. by Feb. 7, the limit of visibility for the great refractor of the Naval Observatory being 16·3. The star had thus, in five months, faded down from "the limit of visibility to the naked eye to that in a 26-inch telescope."

THE GREAT MELBOURNE REFLECTOR.—The great Melbourne reflector was erected in 1869, but until the present time no regular account of the observations made with it has been published. This delay is not, however, to be further prolonged; the first of a series of fasciculi, containing the results of the revision of the Southern Nebulæ observed by Sir John Herschel at the Cape, 1834–38, the work to which the instrument has been chiefly devoted, has just

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* Amer. Journ. of Science, 1886, April.

been published, and others are soon to follow. The present part is largely concerned with an account of the great reflector itself, and contains two good photographs of the instrument and its buildings. As to the performance of the instrument, it is stated that though on ordinary nights it is somewhat disappointing, on *really good nights* its definition is exceedingly fine. Forty per cent. of the nights are said to be fit for observing, moonlight nights being apparently excluded from this category, as unsuitable for nebular work, though used for lunar photography; but really fine nights only amount to seventeen per cent. Some fine results have been obtained in photography, both of the Moon and of stars and nebulæ, but it has not been found practicable to give prolonged exposures to the plates. A number of observations of small nebulæ are given, accompanied by three carefully executed lithographic plates. The curious group of nebulæ Nos. 962, 963, 966, 968, would appear from the observations to have undergone distinct changes, not only since Herschel's time, but in the interval between Mr. Turner's observation in 1876·8 and M. Barracchi's in 1884·8.

ROUSDON OBSERVATORY.—We have received from Mr. Cuthbert Peek the first of the publications of this observatory. It contains a description of Mr. Peek's private observatory at Rousdon, near Lyme Regis, Devon, together with a *résumé* of his astronomical work during the years 1882 to 1885. The observatory seems to be solidly built and very suitably equipped. The principal instrument is an equatoreal by Cooke, of 6·4 inches aperture. The most important of the observations recorded are those of the nebula surrounding η Argûs, made by Mr. Peek whilst at Jimbour, Queensland, whither he had gone in company with the expedition commanded by Capt. W. G. Morris to observe the Transit of Venus. As the observatory was in course of erection during the years 1884 and 1885, no regular work could be undertaken; the principal comets of those seasons were, however, observed, Saturn, the lunar eclipse of 1884, Oct. 4, the Nova of the Andromeda nebula, and so forth—as full a record probably as circumstances permitted. We may reasonably expect to hear of good work proceeding from the Rousdon Observatory at no distant date.

THE SECULAR NUTATION OF THE EARTH'S AXIS[*].—A periodic formula for the secular variations in obliquity and in longitude has been worked out by M. Folie, who, in consequence, applies the term secular nutation of the Earth's axis to these variations. He defines the *normal* equator as a plane the inclination of which to the ecliptic of a certain epoch is equal to the mean obliquity of that epoch, and the intersection of which with this latter plane passes at each instant through the mean equinox of that epoch, and concludes that, in virtue of the secular nutation of the Earth's axis, the mean pole describes round the normal pole, considered as

[*] Annuaire de l'Observatoire Royale de Bruxelles, 1886.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

d by E. W. Maunder, F.R.A.S., A. M. W. Downing, M.A., F
and T. Lewis, F.R.A.S.

tains full Reports of the Meetings of the Royal and Liverpool
al Societies; Articles by various eminent Astronomers, E
ican, and Continental; Correspondence on topics of interest co
the Science; Notes on the progress of Astronomy; Reviews o
al publications; Ephemerides of comets, variable stars, S
tes, and for physical observations of the Sun, Jupiter, &c.;
ual astronomical information.

ongst the contributors to 'The Observatory' in 1885 were Pro
Hall, Holden, Hough, Pickering, Pritchard, and Young
ins; Revs. S. J. Perry and S. J. Johnson; Messrs. Ba
ng, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

is journal is an indispensable complement to the 'Monthly Notices.'"—
mique (organ of the Paris Observatory).

CONTENTS OF No. 110.

ng of the Royal Astronomical Society on April 9 ....
ngs of the Liverpool Astronomical Society ....

les:—

iter's Red Spot and the Region near. By W. F. Denning, F.R.A.S......

espondence:—

Discovery of the Great Nebula in Andromeda. By W. T. Lynn, B.A
F.R.A.S. ....
tography and the Pleiades. By B. J. Hopkins, F.R.A.S. ....
Variable Star η Argûs. By John Tebbutt, F.R.A.S., and A. Stanl
Williams, F.R.A.S. 19

s:—

Zodiacal Light.—Relation of Asteroid Orbits to that of Jupiter.-
Nutation Formulæ.—A French Edition of Oppolzer's Treatise on Orbi
—Astronomical Directory.—The Binary Star 70 Ophiuchi.—The U
Naval Observatory.—The Proposed Change in the Astronomical Day.-
The Maia Nebula.—The Reliability of the Star-places of Auwers' Fu
damental Catalogue.—Photograph of the Normal Solar Spectrum.-
Photographic Study of Stellar Spectra: Henry Draper Memorial.-
Parallax of Nova Andromedæ.—The Great Melbourne Reflector.-
Rousdon Observatory.—The Secular Nutation of the Earth's Axis.
A new Belgian Observatory.—Observations of Jupiter and Venus
1884–85 by Dr. L. de Ball at Liège.—Four new Minor Planets.—Gift
an Observatory to Liverpool College.—Discovery of a New Comet... 1

neris of Comet Fabry. By Dr. S. Oppenheim ....
neris of Comet Barnard. By Drs. H. Oppenheim and Hepperger ......

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 111. JUNE. 1886.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, May 14, 1886.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel, and
Lieut.-Col. G. L. Tupman.

The Minutes of the previous Meeting were read and confirmed.

Col. Tupman. Eighty-two presents have been received since the last meeting. Amongst those calling for special mention are some more of the beautiful and truly wonderful productions of the Messrs. Henry of Paris. The first is a beautiful engraving of one of their photographs of the group of the Pleiades showing the three nebulæ and stars down to the 16th magnitude, the smallest magnitude that has been yet photographed. There is also a large photograph of part of Gemini and several photographs of Jupiter.

A vote of thanks to the donors, and especially to the Bros. Henry, was then passed.

Mr. Knobel. In the photograph of Jupiter the red spot is more conspicuous than it appears to direct observation through the telescope, and the same is the case with the shade upon the following limb of the planet. These facts show the beauty and perfection of the photographs, which are in my opinion quite unique.

Mr. Ranyard. The differences in light intensity as perceived on the photograph and by the eye are more striking than in the photographs of Saturn.

The President. The first paper is on the Proper Motions of 29 telescopic stars by Dr. Dreyer, and as he is present I will invite him to come forward.

Dr. Dreyer. The subject of this paper is the discussion of the proper motions of 29 stars, nearly the whole of which are below the 6th magnitude. Proper motions of faint stars are by no means so scarce as has been supposed. We now know about 600 or 700 telescopic stars which undoubtedly have proper motions. The principal list of these stars is in the 1st and 2nd vols. of the Bonn Observations and it contains 250 stars. There is a second list, hitherto unpublished, also by Argelander. Some two or three years ago I quite accidentally came across Argelander's results in a German publication, by Dr. Bischoff, in which the latter investigates the direction of the proper motion of the solar system by means of these 480 Argelander stars. During the last few years I have been almost exclusively occupied with the preparation for the press of a new catalogue founded on the observations at Armagh since 1859; and during that work I have come across a considerable number of stars which appear to have proper motions. First of all I had to see that these stars were not old friends contained in those two papers by Argelander, and next to see whether they had been found before by other investigators. In many cases I found it so; but when I could not find that was the case I put together the materials for their proper motions and the result of my examination I have given in this paper. We are at present labouring under several disadvantages in determining the proper motions of many of these stars. There are not only the systematic corrections for different star catalogues,—in which a good deal has been done of late years, though perhaps some of the systematic corrections are not well founded,—but secondly, what is more important, we are to a great extent thrown back on the zone observations of Lalande and Bessel, in which there are errors that make one cautious in using them for such a purpose. Not only have many of Bessel's zones been found to have very considerable systematic errors, but many of Lalande's stars are remarkable for errors of one second, which probably arises from the way in which those observations were made. The observer did not himself note the time of transit, but called out "now," or some such word, to an assistant who noted the clock, and probably the errors of exactly one second in each case occurred in that way. I only mention this to show that some caution is necessary. Still I have thought that my humble contribution to this important department of sidereal astronomy may have some value, if not to give the accurate values, at least to draw attention to the subject. Another circumstance that may be mentioned is that we shall be very soon in possession of more important and valuable observations than could be taken with the instruments in use at Armagh. The Paris Observatory has been engaged in redetermining all the stars in Lalande's catalogue, which will be included in one great Paris catalogue, and we may expect to see a large catalogue from the Brussels Observatory, where stars with proper motion have been particularly observed for number of years. When I have found a star occurred in not more than two old catalogues, I have determined the amount of proper motion by the method of least squares; and when I have found the star only appears in Lalande's and Bessel's catalogues, I have taken the mean of the two. I will only add that it is highly desirable that these stars should be observed from time to time so as to determine more accurate values for their proper motions.

The President. Dr. Dreyer has spoken very modestly of his own interesting paper. I will now invite comments upon it from the Fellows of the Society.

Capt. Noble. Dr. Dreyer referred incidentally to some researches of Dr. Bischoff, and as I have never heard of them before, I should like to know whether his results bring out the same apex of the solar motion as that with which we are so familiar in the text-books.

Dr. Dreyer. Yes; as far as I remember, the result was very much in accordance with what is generally adopted.

Mr. Knobel. Do I understand Dr. Dreyer to intimate that there is a paper of Argelander not yet published containing the proper motion of some telescopic stars?

Dr. Dreyer. Yes: the only time I have seen this paper mentioned is in an obituary notice of Argelander, which appeared in the 'Vierteljahrsschrift' in 1875 or 1876; and at the meeting of the Astronomische Gesellschaft at Hamburg in 1873, I remember Argelander read a short paper on some new proper motions, and I know there was a short abstract of that paper published in the 'Vierteljahrsschrift,' but that only gives the results for a small number of stars, whereas the paper which I suppose was intended to be published in the next volume of the Bonn Observations contained 230 new stars.

Mr. Knobel. Does Prof. Schönfeld possess the manuscript?

Dr. Dreyer. No doubt he does, and it will appear in one of the next volumes of the Bonn Observations. The result of the proper motions is given in this pamphlet.

The President. Might I ask whether the error of one second in Lalande's observations is perfectly well recognised, or whether its detection has resulted from your own inquiry?

Dr. Dreyer. I think it is perfectly well known; Argelander calls attention to it in his well known list of errors, which is also published in the 7th volume of the Bonn Observations. I am not aware, however, whether any one has remarked how frequently errors with the plus sign occur.

Mr. Knobel. What explanation do you give of this curious error?

Dr. Dreyer. That two observers were engaged, one looking through the telescope and saying what he saw, while the other looked at the clock and noted the time. You can easily imagine that a person might have the peculiar habit of making an error of one second. Again, in many cases he only gives the second without adding any decimal; but we cannot be sure that these are mere rough observations, because if we compare a number of cases it is evident he has added a *nought* in the decimal place or left it out at random; so that every case has to be considered on its own merits. But, all the same, the 'Histoire Céleste' is a perfect treasure to us, because Lalande and his nephew were almost the only people who observed these stars.

Mr. Grubb described, by means of a model, the working of a
observatory he had designed in competition for the Trustees of th
Lick Observatory, California. He said :—About three months ag
the Trustees of the Lick Observatory invited me to design an equa
toreal mount and dome for the great 36-inch refractor, the glass
of which Messrs. Clark of America are now working. They men
tioned at the same time that a similar invitation was sent to thre
other optical firms. In working out the design, I found it desirabl
to make a model : and a description of this model may be of interes
to the Society. The model is not to be considered as an accurat
scale model of the design, as it was made before the design ; bu
it is sufficient to illustrate the principle of the scheme I hav
endeavoured to carry out. The idea I have had all through is t
bring under the direct control of the observer all the require
motions of the instrument and of the dome, so as to give him a
little physical exertion as possible. The object-glass is 36 inche
in diameter, focus 57 feet, the dome 70 feet internal diameter an
86 feet external. To carry out my idea I have arranged that ther
shall be four small water engines—one to give motion in R.A.
another in Declination, a third to move the dome, and the fourth
for the purpose of bringing the observer himself into the prope
position for observing. These water engines I propose to contro
by an electrical apparatus which the observer will carry about with
him ; but as it is undesirable to give electricity too much to do in
an observatory, I do not propose that it shall be used for opening
and shutting the valves of the engines directly ; that will be
done by a mechanism which is supposed to be wound up every day
by an assistant and consists of a barrel and a few weights. Thi
apparatus will open or close the valves, and will be the one worked
by electricity. In this model the engines are represented by a
small piece of clockwork, and the clockwork is controlled by little
electric magnets. The idea is that when the observer enters the
room he should find at one door an apparatus of this sort. [A
small case with 9 keys controlling the electric current and of a size
convenient for the pocket.] A tap on one key will turn the dome
in one direction ; another will reverse the dome ; a third key will
control the telescope in R.A. and another in declination, and so on
while there is one for lighting up the observatory ; and lastly, in
order that the observer shall have as little difficulty as possible in
getting into a position to observe, instead of climbing into a chair
which would perhaps require to be 25 feet high, here is a key
which will make the whole floor move up or down. Mr. Grubb then
explained his method of arranging the shutters of the dome so that
the dome should not be weakened, and also the manner of opening
and closing them ; and, lastly, he said, as a matter of precaution
against accident by touching the wrong key and so bringing the
telescope in contact with the observer, he had provided at the end of
the telescope weights hanging three feet below the eyepiece, and
so arranged that if the weights touched the ground that would cut
off the water supply and the floor would cease to rise.

The President. It makes one feel very envious to think of the luxuries to be provided for astronomers of the future. The most charming part of it is the movement of the floor. I suppose the staircase is made to reach the floor from the outside, and that the floor may be at any level. Of course, on a scale of 70 feet one can appreciate what the size of the appliances will be. It seems as if the life of an astronomer, with simply a key in his hand to touch in order to make these movements, would be something one could dream of but could scarcely hope to realize.

Capt. Noble. We may suppose that the door moves with the floor, otherwise a gentleman might go in at the top, say after dinner, and the floor might be down 30 or 40 feet, and then the observation would be spoiled.

Mr. Common. I have had the pleasure of seeing this model at the Royal Institution when Mr. Grubb gave his lecture a few weeks ago, and I was very much struck with the most ingenious arrangements he has here. I rather fancied at the time that it was the actual model of what they were going to have at Lick, and and I, like our President, rather envied them their luxuries. It is not to be so, I understand.

Mr. Grubb. It is merely a design as yet; whether they will accept it remains to be seen.

Mr. Common. I had a letter from Prof. Holden the other day which may be of some interest. Prof. Holden says:—"The glass for this lens," referring to the telescope, "is now available, and we hope during the early part of 1887 that we may see the objective, both photographically and visually, completely finished, and perhaps delivered in California. Our large dome will undoubtedly be finished during the current year; and we look forward to commencing serious work with the whole observatory during the year 1887, and possibly sooner." That rather shook my faith in what I had previously conceived to be a settled thing—that this was going to be the Lick dome; and I saw in last month's number of the 'Century Magazine' (I do not know whether it was a hash-up of an old idea) an idea which was projected by a young engineer who has carried out most of the work at Mount Hamilton, and who proposed a dome which is called a seven-eighths dome. [Mr. Common then drew on the blackboard what he believed to be the pattern of the dome, and also described a method he had communicated to Prof. Holden for a mercurial floating of the dome.] Apart from that, I must say that every thing that contributes to the comfort, or to the ease, or to the dispatch of business of the observer while he is observing is of the utmost importance. Any care or trouble taken in the preparation of an instrument to enable a man, when fine weather comes, to use the telescope to the utmost extent of which it is capable is a distinct gain, and multiplies not only the comfort of the observer but the value of the instrument; because if you have one large instrument only working half-time, it has only half the value which it would have if it were working full time. Prof. Holden says—"It is my hope that we may be able to keep it at work during the larger part of the 24 hours, day and night."

Mr. Stone. May I ask if there is not a certain amount of danger in using water power? On certain occasions our water freezes; but of course all these ideas may be carried out with any other motive power as well as water. With regard to the idea Mr. Grubb wishes to carry out, all I can say is one must wish to go over life again to have such an instrument. Any one who has employed an instrument of large size, and has had to move it about and the dome and the chair, and has made observations in the ordinary way, will know how excessively knocked-up one feels at the end of a long night, and thnt he could have done a good deal more had this contrivance been in his hands.

Mr. Grubb. With regard to Mr. Stone's question, I have made inquiry. I had the choice of steam, gas, or water as a motive power. Steam I thought to be rather impracticable: as to gas, I was not aware that they had gas there. I then inquired with regard to the matter of freezing; and I was informed that they had hardly any frost whatever there, as the winter was very mild. As Mr. Stone says, any other motive power could be applied in the same way. As to Mr. Common's remarks, he has touched upon the contract and the time, so perhaps it might be interesting if I mentioned to you that it is about three months ago since I was first applied to. I was told that the estimates for the equatoreal should be in San Francisco on the 1st of May. Subsequently they applied for an estimate for the dome. Of course in sending in an estimate for the equatoreal I was obliged to include the dome as a portion of the system; but afterwards they sent for an estimate for the dome, and said that the estimate should be in San Francisco by May 15, and that the dome should be complete and in working order in the month of October this year. It would be impossible to get matters arranged until July 1 at the earliest date; and allowing a month for shipment and a month for erection, it will leave me one month to make it, and the construction of the dome would involve spending £4000 in wages. I had to inform them that they would have to turn months into years. That is as far as I know about the state of affairs, so that it rather tallies with what Mr. Common says about Prof. Holden expecting to have everything ready this year.

The President. Whether the actual construction of the dome for the Lick Observatory falls to Mr. Grubb or not, I am sure we are indebted to him for bringing before us this beautiful model. At all events it is exactly what the astronomer does need—that he should be able to hold in his hand a handle, and be able to press down different buttons on that handle, and so be able to move the telescope or the floor just as he pleases. That is what astronomers will come to in the future. This model marks a step in the progress of astronomy; and it will probably be only a few years hence before the astronomer will be able to devote his whole energy to observing what he sees through the telescope without having his time and thoughts occupied in what can be done so much more easily by the method Mr. Grubb has explained.

Dr. Leonard Waldo, of Yale College, was then called upon to describe a new escapement. He said:—I am sorry, but a sick child of a countryman of mine claimed my attention up to the time of coming to the meeting, or I should have brought with me an escapement which represents the progress we have made on our side of the water in the study of clocks of precision as far as the escapement goes. Under these circumstances it may perhaps be interesting if I review the experiments which have been made, largely under my direction, with the view of attempting to measure the hour with the same proportionate precision with which we can measure the day. The ordinary clock theory assumes that our pendulum swings in a plane; that it has a given arc of vibration; that the variation in the arc is compensated by a change in the velocity of motion of the pendulum; and a good many other assumptions which will not bear close investigation. Perhaps there has been of late years more attention than usual devoted to standards of all kinds on the other side of the water, and having the facilities of one of our large clock companies, the Seth Thomas—and their facilities were very great indeed—it fell to my portion to undertake an examination of clocks of precision. I introduce that term to distinguish it from the ordinary clock of the observatory, which, in general, is more or less exposed; and we all know how barometric and thermometric changes introduce gross errors in clocks; and there are more or less obscure errors which may be called differentials of a higher order, and these differences of a higher order depend on such obscure causes, as want of pendulum vibration in a plane, mobility of the support, change of the coefficiency of the elasticity of the suspension spring, change of temperature, change in the arc of vibration, want of conformity in the arc to a truly circular or cycloidal arc, as the cause may be. In the first place it was very clear indeed that when we compensated the ordinary steel spring suspension-pendulum we compensated the change in the spring itself, which takes place on a change of temperature, and that quite as much as the change in the length of the pendulum. A great deal of attention has been paid to the actual change in the lineal dimensions of the rod corresponding to the change of the steel or glass jar at the base, while little attention has been given to the change in elasticity of the suspension itself; but that is an important consideration. Therefore the first question was to see whether the pendulum could not be swung in some other way. I did not quite see how to swing it in any other way; but Sir William Thomson said he would like to show me a clock in which he had carried out the idea on which I had worked. He said he had swung a pendulum on an agate knife-edge, circular at the top. I saw it yesterday. I had thought out the idea of having a suspension analogous to that, and had made one two years ago; and the two suspensions are identical. I had also been experimenting with glass rods, the coefficient of expansion of glass being much less than that of steel or platinum; and the temptation is great to use glass rods in pendulums; but I have not been able to get a glass bar which satisfies me. Sir William Thomson showed me his pendulum with an agate suspension and a glass bob at the bottom; and mechanically the difficulties have been overcome with one exception, namely, that I do not see that he had any guarantee that the inside of the glass bob was a true cylinder. In any glass-blowing the imperfections of the cylinder are of the utmost consequence, because no compensation can take place worthy of the name in a precision clock, unless it is a true cylinder. I rejected glass because I did not see the way to get in a cylinder homogeneity of the rod. All the efforts I made to get absolutely straight rods were failures. We may succeed; but at present we have gone back to steel jars with steel rods, but with this difference, that the pendulums have very heavy bobs of from 40 to 60 lbs. You will remember that in the theory of clock-errors all the errors are represented by an expression in which the sum of a certain number of errors is divided by a constant a multipled by the length and by the weight of the pendulum itself. There are two reasons why the length of the pendulum cannot be very well increased: one is the second unit of time, and the other that no compensation yet contrived has given the actual results which mercurial compensation has, and with a mercurial compensation the pendulum should be short, so that the top and bottom may not greatly differ in temperature. The best pendulums made by Kessels, the Hohwu clocks, those made by Tiede of Berlin—those which show the best performances—are clocks where mercurial compensation has been used; and, I take it, it is owing to the extreme sensibility to change which we have when a liquid flows instead of a solid expands. That expression shows us the necessity of increasing the weight of the pendulum; and therefore the pendulums in these clocks are very heavy, from 45 to 60 lbs. of mercury, for the ordinary mercurial pendulum. There are two other things ordinarily in the pendulum jar besides the mercury—bubbles of air and oxide of mercury. The centre of gravity, by the solution of the oxide of mercury, changes; and therefore the mercury must be pure and free from air. So much for the pendulum. The next consideration is the loss of motion in the escapement. Now, while in an ordinary counting-clock the best escapement is a Graham escapement, yet when you put it a distance from the observer, using it not only as a standard of time, but to drive electrical devices for recording in some other part of the observatory, the Graham escapement will not do, because any additional work directly affects the escapement itself. On that account I think some form of detached gravity-escapement is the escapement of the future; and the point of the application of that escapement is an important consideration. In Brequet's escapement the point of application is at the base of the bob; but I prefer the established type for applying impulse. I began to experiment with Dennison's gravity escapement, which is quite a favourite in the United States, because Messrs. Howard have made some of their best clocks with that escapement. But Dennison's escapement requires a large amount of power to drive it, and I have never seen a Dennison gravity escapement which did not stop in two years unless the driving-weights were very heavy; and that is a serious interruption where you are conducting observations. I took it that the great difficulty with Dennison's escapement lay in the fact that the machine is a train of wheels, which should start at the end of every second from a state of absolute rest at a certain velocity and throw its arms out in time to be locked before the second closed, but after working for some while it fails to get up sufficient velocity unless the train of wheels is allowed to sustain a weight utterly out of the question. Therefore I adopted a very simple device suggested by Professor C. S. Lyman, one of those men who unite to theoretical a knowledge of mechanical science to a very high degree. He suggested putting a large friction-roller in one of the arms of Dennison's escapement, and to lift that arm by an equilateral triangle which, in a position of rest, should be by the side of the friction-roller. When the arm is lifted it is by the rotation of this triangle on its axis. Then the clock begins to lift it with a very small velocity; but as the triangle rotates on its axis it will be with an increasing velocity until the arm is lifted up, having its maximum velocity just as it stops. By this means you can drive a heavy pendulum with the driving-weight reduced to a minimum, and the certainty of action increased to the maximum. Having adopted the form of the pendulum and the escapement, then comes the very important question of providing a rigid support for the pendulum. I have adopted two piers of heavy masonry work, just as in the support of a massive transit-instrument, with a massive iron arch on the top from one pier to the other; and from this arch, bolted down, the pendulum can swing, and then the dial and the escapement can be put on a bracket inside the piers. This construction admits of a plate-glass back and front, which can be made airtight, and the space can be filled with hydrogen or air at any pressure. I have a little vernier attached to the pendulum, swinging across the arc reading-scale at the middle of the rod. Built around the piers are coils of steam-piping, for regulating the temperature, and an electric-thermometer regulator made of a layer of zinc and steel or steel and rubber. These are the salient features of the experiments I have been carrying out for a couple of years back. I can only say we have passed a point of present attainment of certainty in clock-rates of precision when perhaps the total amount of average deviation will be lessened by 25 per cent. That I regard as the probable estimate of the value of such precautions in the clocks built on this principle and in the best forms of timepieces. We now have the great advantage that you can, by means of auxiliary relays outside the clock, transfer the precision clock, which may be in a cellar or well, to any part of the observatory. As to the immediate differentiation of this species of clock, we now load up the impulse-giving apparatus of the pendulum, and if we require to move the hands or drive the train we send electric signals all round the observatory. But that is wrong; there ought to be an auxiliary in the clock, driven by another pendulum, say a half-second's one, for doing that special piece of work. That idea was carried out by Richard Bond, the brother of W. C. Bond, of Harvard College, by means of his gravity escapement. There is a clock of that kind in the Liverpool Observatory at Bidston, and I have seen another at Sir William Thomson's. He has the auxiliary work done by an auxiliary pendulum, as it should be: and undoubtedly that will be the next step of progress in the construction of such clocks of precision.

The President. We are very much obliged for the interesting account given by Dr. Waldo of his researches on the subject of clocks. (Hear, hear!)

Mr. Buckney. I should like to make a few remarks on what Dr. Waldo has stated, because his experience disagrees with mine. First, with regard to the pendulum, I take it he considers the mercurial pendulum is far better than the zinc-and-steel one. My experience has shown quite the opposite. I very much prefer the zinc-and-steel pendulum. I found, some years ago, in making experiments, a great many errors in the mercurial pendulum; at any rate, one particular error it seems to possess, and the more you increase the size of the pendulum the more you aggravate that error. In the mercurial pendulum the change of temperature acts first of all on the vessel containing the mercury and will change its dimensions. If you expose an iron vessel containing mercury to a sudden change of temperature, such as putting it suddenly into warm water, the first effect of that increase of temperature is, instead of making the mercury rise, the mercury falls in the vessel; that is due to the sudden change of temperature causing the cylinder or jar to expand before the temperature has time to act on the mercury. The effect is transient. The mercury soon recovers itself and takes up the change of temperature; but some time elapses, and of course during that time the clock is losing. I also made some experiments with regard to the advantages of different sizes of mercurial pendulums, and I found that a mercurial jar of 2 inches in diameter, which is the ordinary size used, when exposed to a certain temperature, having a wide compensation error, took about one day to steady itself with a change of temperature of about 30 degrees. A jar of 3 inches in diameter took two days, and sometimes three, and the cooling was effected in about half the time. The increase of temperature took about double the time to show itself that the cooling effect did. That I cannot account for; but I mentioned it to Mr. Glaisher, the father of our President, who was then at the Royal Observatory, and he mentioned that he had noticed the same thing with thermometers. Then I found that the compensating effect took very much longer in a mercurial pendulum than in a zinc-and-steel pendulum, and that arose from the mercury being in large masses, and the change of temperature took some time to produce an effect upon the mass in the bob. With the zinc-and-steel pendulum, however, there is simply an arrangement of rods and tubes going up and down; they are generally tubes outside a central rod, and the bob is suspended from the outer tube at its centre. By suspending the bob at the centre, you eliminate any errors owing to the expansion of the bob itself. You depend for the compensating effect upon the zinc and steel forming the rod of the pendulum. Now these metals are pretty much of the same mass, and any change of temperature affects them almost simultaneously, which is a very great point. But in the mercurial pendulum you have the rod itself comparatively small, and no doubt a change of temperature causes the rod to lengthen some considerable time before the mercury takes up the new temperature and expands so as to produce the compensating effect. Those are points which struck me as to the pendulum. As to the escapement, the detached and Graham escapement appear to me to answer exceedingly well; and with regard to electric contact apparatus applied to an escapement of that kind, the only point essential is that the impulse should be completed before the electric contact is made, so that the impulse given to the clock should not be interfered with or affected in any way by the act of making the contact with the springs. With regard to the suspension of the pendulum, I think it is admitted on all sides that it cannot be too rigid. I think it may be done in another way than that shown by Dr. Waldo. I have generally adopted the plan of a massive bracket bolted to masses of metal let in the wall, with, of course, a planed surface and accurately fitted. With masses of metal let into the wall and fastened with strong bolts there is a very rigid suspension, which is the essential point; but it does not much matter how it is done.

Mr. Inwards. There is another objection to the mercurial pendulum, though a small one; and that is that the mercury must, to a certain extent, flop about in the pendulum, and that must be equivalent to so much friction.

Mr. Common. With regard to the gravity escapement, I have always noticed that its arm, upon which the power to keep the pendulum going depends, always swings from the ordinary arbor which is oiled in the usual way. When we consider the effect of the slightest stickage in the oil, it must make an enormous difference to the amount of the impulse given to the pendulum. If clock-makers will do away with this arbor and substitute an analogous arrangement and make it a spring suspension, a great deal of difficulty will be got rid of. Another point, any unsymmetrical pendulum has always a tendency to wobble, and the wobble is pretty constant without any regard to the steadiness of the support. There is also a constant tendency of the pendulum, in consequence of the motion of the earth, to change the plane of oscillation. There is one point on which both Mr. Buckney and Dr. Waldo were very reticent, and on which I feel sure a good many practical astronomers would be glad of a little information. They all talk of making contact in working clocks; but the question is, how are those contacts made? Every man who has tried to make them, so far as I know, has found a considerable difficulty, and no doubt we should be glad if some really practical plan could be shown by which an ordinary gravity-clock dead-beat escapement, or some really good electrical direct contact apparatus, could be applied for the purpose of using either the chronograph or a secondary pendulum.

Mr. Bryant. The question of the change in elasticity in the supporting spring, due to a change of temperature, was called attention to by Dent twenty years ago, I think.

Dr. Waldo. These criticisms have interested me very much indeed; I do not know whether I can remember all the points brought out, but they have all claimed a good deal of attention. In the first place, about the zinc-and-steel compensation, I am sorry to take up the cudgels on zinc-and-steel versus mercurial compensation; but I would like to say, that if any one can point out to me a case in which a zinc-and-steel compensation has been thoroughly investigated, and can show me papers or figures in which its excellence in actual work has been shown, I shall be very much obliged to him, for I have sought far and wide for just that kind of literature. I know the first thing you will say is, "Go to the Greenwich observations and you will get a complete investigation of the pendulum;" but unfortunately you do not get anything of the kind, and when you go you find the clocks have only been running without interruption for comparatively short intervals. I can assure you that accurate observations of clock-rates under varying conditions, with all the quantities measured, are exceedingly rare and difficult to get, and of all the observations made I think you will find that those observations with the mercury and steel pendulums give the best results. But I have a second point: Gen. Comstock, of the U. S. Lake Survey, pointed out very clearly that for a standard of length zinc cannot be employed. It has a certain coefficient of expansion, and after it has cooled down again it never takes up the same position. The "swish" of the mercury in a pendulum with mercury bob I regard as a valuable thing to point out, because it has given me a great deal of trouble, and I had a very interesting discussion with Prof. Young at a time when his escapement was under discussion. I regard the idea of having parallel cylinders and mercury as a bad one, because of the difficulty of having in these matters the metal expand in a uniform direction and having two cylinders parallel to themselves. Therefore I prefer to either put up with the evil, or else have the work extremely small. I frankly acknowledge that is a difficulty, and one which has not been surmounted, except by the clumsy expedient of having a number of parallel cylinders, and then the precision of the instrument is not sufficiently great to be sure that they all expand quite uniformly. Another point was the suspension of this gravity arm. I have made this pivot run in a dry jewel hole, but it may be better to have it with a spring or on friction-rollers. The elder Bond, who built a most beautiful specimen of workmanship, has springs in his gravity escapement. In designing these clocks I queried a long time whether to put the springs in them or to let the arms swing as they do. I heartily sympathize with the gentleman who remarked about making contact in the clocks, because of all the difficulties in a chronographic system of registering this is the most serious. I can only say how I make contact in this clock and what means I use outside the clock. I do not say it is the best; I only say it gives very satisfactory results. In the first place, contact fails to work because the oxide in the metal that forms the support leaves some dirt. If you use platinum and gold joints in making contact you will get a little less spark than with any other common metals; that is merely a shop dodge, I do not know why it should be so. A clock I have, made in that way, has been only running eight or nine months, so next year I may have all the trouble again. I merely give this as a present solution of the very difficult little problem of how to make this contact inside a clock. If you want to get rid of the spark it is a simple device to put in a shunting coil of German silver wire. Outside the clock entirely, and at very convenient distance from it, you can then put a relay, worked from the points in the clock. This relay is in circuit with the local battery, chronograph, and observer's key. The points of this relay are mercury cups, into which the two arms of a copper U plunge with every downward stroke of the relay armature, and make the circuit. I usually cover the surface of the mercury with a mixture of equal parts of alcohol and glycerine.

The President. The meeting have already thanked Dr. Waldo cordially for his lecture. I can only say this is the first time I have heard a discussion on the relative merits of mercurial and gridiron pendulums, and I have listened to it with the greatest possible interest. I have often wondered that the merits of those things have not been discussed at all in any book.

Mr. Green wished to make some remarks on the observations of Mars made by Mr. Knobel in 1884 (Mem. R. A. S. Vol. xlviii. part ii.). Mr. Green spoke in high terms of Mr. Knobel's observations, many of which he had been able to confirm in the most satisfactory manner, though he differed from him occasionally. Mr. Knobel considered that Mr. Green's chart required modification near "Knobel Sea," as he found dark bands instead of the light space called "Leverrier Land." Mr. Green had seen this space clearly in the opposition just past. Both series of observations afforded, however, additional proof of the changes many of the Martial markings undergo from time to time. The "Lassell Sea," which was, during the late opposition, almost as distinct as the "Oculus," and "Huggins Inlet" were cited as examples. Mr. Green referred to Mr. Knobel's criticism of his nomenclature and proposal for substituting numbers and letters, and remarked that at all events Mr. Knobel seemed to find the names very convenient.

The President said that he regretted Mr. Knobel had not been able to remain to hear Mr. Green's remarks.

The following papers were also announced:—

G. W. Hough. "Observations of the Companion of Sirius made at the Dearborn Observatory, Chicago."

W. F. Denning. "Jupiter's third Satellite in Transit April 11, 1886."

J. E. Gore. "Observations of the New Star in Orion."

W. F. Denning. "The Meteor-shower of Halley's Comet."

B. J. Hopkins. "Note on a Remarkable Sun-spot."

Rev. T. E. Espin. "Photographic Photometry, Zone + 40°, 0^h–1^h."

Royal Observatory, Greenwich. "Observations of Comets *d* 1885 (Fabry), *e* 1885 (Barnard), and *a* 1886 (Brooks)."

E. J. Spitta. "The IVth Satellite of Jupiter during Superior Conjunction on the night of April 5, 1886."

A. M. W. Downing. "Comparisons of certain Southern Star Catalogues."

The following gentlemen were duly elected Fellows of the Society:—William Edgar Butcher, J. D. McClure, B.A., and Charles Ridley Smith.

The Meeting adjourned at 10 P.M.

Liverpool Astronomical Society.

THE last meeting of the Session was held on the 11th inst., Mr. Isaac Roberts, F.R.A.S., President, in the chair. Mr. W. H. S. Monck, M.A., was elected a member of the Society.

A paper by Miss Brown, upon the remarkable Sun-spots which appeared at the end of April and beginning of May, was read.

The following statement concerning the Society was made by the President:—

I may be permitted to refer briefly to the present position of the Society, in order to give some information concerning it to the members who have not been able to attend any of the meetings or to take part in the management of its affairs.

The Society was formed "with the object of fostering a liking for Astronomy and to encourage Astronomical observation, especially amongst the possessors of small telescopes."

Two gentlemen took the chief part in its formation, and for a time conducted its affairs with energy and prudence; but in the third year they had largely extended its scope by inviting members resident in distant parts of the country, as well as others who are resident in foreign parts, to join it. Several gentlemen of eminence as astronomers were also induced to countenance a Society so active in the promotion of astronomical study by becoming honorary or associate members.

The members of the Society now number 239, and are classified as follows :—57 reside in Liverpool or within 12 miles distance, 148 reside in different parts of Great Britain and Ireland, 16 reside in foreign parts, and 18 are Associate Members. The latter are not subscribers to the funds of the Society and receive the printed Journals free of charge.

The annual subscription of members is five shillings, and the business of the Society is conducted by a Council consisting of 19 members, 9 of whom reside within 12 miles of Liverpool, 10 reside in differents of England and Ireland, and these have to be consulted by correspondence. A Society formed on the bases here described has weak points, and these were made manifest at the commencement of the present Session, as the sequel will show.

Firstly. The gentlemen who had been the chief actors in forming the Society and in extending its scope so widely, found out that they had undertaken heavy responsibilities in correspondence and literary work, which I infer became irksome to them when the novelty of their position settled down into routine work.

Secondly. The annual subscriptions were inadequate to meet the expenses of printing a Journal and the other necessary charges in conducting the Society, consequently a considerable amount of liability was incurred without funds to meet it.

This was the state of affairs which the President and Council found existing when they entered upon the duties entrusted to them after their election to office; and to add to these difficulties the gentlemen who had created them not only withdrew their assistance, but acted in a manner to retard the necessary work of reorganization.

The financial state of the Society at the present time is such that, by exceptional contributions made by a few of the members and economy practiced by the Council, it is freed from debt.

As to the future of the Society I am not in a position to predict, but I feel it my duty to invite the consideration of the members of the Council who reside so far from Liverpool that they cannot attend the meetings, and also the consideration of the members of the Society generally, to the following facts :—

Firstly. The correspondence and literary labours connected with a Society constituted on the basis of this are so arduous, that it is not reasonable to expect any competent Secretary to undertake them as hitherto, without pecuniary remuneration.

Secondly. The number of members resident in Liverpool who are willing to give the time necessary to the work of the Council is very limited, and I may here speak also for myself that at the expiration of the Session I shall be unable to devote any part of my time to the service of the Society.

If, therefore, it is to be successfully conducted as a large one publishing Transactions, the annual subscriptions will have to be considerably increased and competent officers will have to be found who are willing to devote the time requisite to conduct efficiently and continuously the business of the Society. I would suggest that those members who take great interest in its well-being should between now and the date of the Intersessional Meeting in June communicate their views to Mr. R. C. Johnson, of 19 Catherine Street, Liverpool, member of the Council, to whom, and to Mr. Appleton and Mr. Sharp, I am greatly indebted for valuable assistance in conducting the work of this Session. By so doing some practicable plan may be devised for continuing the Society in a manner that may realize the object set forth at the commencement of its career as quoted in this communication.

The Density of the Sun compared with that of Algol.

In a lecture by Mr. J. Norman Lockyer, reproduced in 'Nature,' Vol. xxxiii. pp. 399 &c., my attention was attracted by his remarks on the density of the Sun, especially where he argues that, although the radius of the photosphere is only 430,000 miles, yet the true radius for such consideration is much larger, and perhaps as large as 930,000 miles. This reduces the mean density of the Sun to about one eighth that of water. And then he says—"If these arguments are of any value, we must concede that the density of the Sun is very low indeed, much lower than that of any planet or satellite with which we are acquainted; so that we are perfectly justified in saying that it is an enormous globe of gas, by which I do not mean that it is absolutely and completely gaseous to the core. The gases of the centre—gases under very great pressure—may put on the appearance, if they do not put on all the physical properties, of liquids; but be this as it may, in any region that we can get at, unfortunately limited to something like 400,000 miles away from the centre, we are undoubtedly dealing with masses of gas."

It is nearly twenty years ago since I arrived at the same conclusion with regard to the star Algol; and the following notes now produced may perhaps at least deserve attention.

Respecting this star Sir John Herschel wrote in his 'Outlines of Astronomy':—"It is usually visible as a star of the second magnitude, and such it continues for the space of 2 d. 13·5 hr., when it suddenly begins to diminish in splendour, and in about 3·5 hr. is reduced to the fourth magnitude, at which it continues about 15 min. It then begins again to increase, and in 3·5 hr. more is restored to its usual brightness, going through all its changes in 2 d. 20 hr. 48 min. 54·7 sec. This remarkable law of variation certainly appears strongly to suggest the revolution round it of some opaque body, which, when interposed between us and Algol, cuts off a large portion of its light; and this is accordingly the view taken of the matter by Goodricke, to whom we owe the discovery of this remarkable fact in the year 1782."

Assuming that the brilliant and dark bodies are both spherical, and that their radii are r and r' respectively, we may easily compare r and r' by means of the total diminution of light—the continuation of the minimum for 15 min. assuring us that the disk of the dark body, could it be seen by us during the eclipse, is wholly projected within the disk of the brilliant body.

Thus, if the light at maximum be taken as 40 and the light at minimum as 6·3, we have

$$\left(\frac{r'}{r}\right)^2=\frac{40-6\cdot3}{40},$$

so that

$$\frac{r'}{r}=0\cdot92.$$

Again, since the radii of the two spheres are so nearly equal, the eclipse must be nearly central; and consequently, if a be the radius of the orbit of the dark body round the centre of the brilliant body, which it will be convenient to suppose fixed, as 3·5 hr. is equal to 210 min., and the whole period is 4129 min., we easily obtain the following relations, assuming that the orbit is circular—

$$\frac{2(r-r')}{2\pi a}=\frac{15}{4129},$$

$$\frac{2r'}{2\pi a}=\frac{210}{4129};$$

whence $\quad \frac{r}{a}=0\cdot171, \quad \frac{r'}{a}=0\cdot160; \quad$ and $\frac{r'}{r}=0\cdot93,$

which is independent of the assumed circularity.

This agreement of the values of the ratio $\frac{r'}{r}$, as found by the independent considerations of light and motion, is very remarkable, and gives weight to the investigation.

Now if m and m' be the masses of the two bodies, and if p be the period of the dark round the brilliant body, we have from physical astronomy,

$$p^2(m+m')=4\pi^2a^3.$$

Let d be the mean density of each of the two bodies, then

$$m=\frac{4}{3}\pi dr^3, \qquad m'=\frac{4}{3}\pi dr'^3,$$

and the equation becomes

$$dp^2\left(\frac{r^3}{a^3}+\frac{r'^3}{a^3}\right)=3\pi;$$

or substituting the known values of the ratios, and dividing,

$$dp^2 = \frac{3\pi}{0{\cdot}00910} = \frac{3\pi}{(0{\cdot}2088)^3}.$$

Similarly, if D be the mean density of the Sun, namely 1·444, taking his radius as 430,000 miles and water as unity, and if P be the period of the Earth in her orbit round the Sun, we may obtain

$$DP^2 = \frac{3\pi}{(0{\cdot}00461)^3}.$$

Therefore

$$\frac{d}{D} = \left(\frac{P}{p}\right)^2 \left(\frac{0{\cdot}00461}{0{\cdot}2088}\right)^3 = 0{\cdot}175;$$

so that $d = 0{\cdot}25$, or one fourth that of water. And in the case of the components of Algol, as Mr. Lockyer argues in the case of the Sun, we are undoubtedly dealing with masses of gas.

Jamaica, 1886, April 8. MAXWELL HALL.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Liverpool Astronomical Society.

GENTLEMEN,—

A statement was read by the President at the last meeting which has been fully reported in the 'English Mechanic.' It is reasonable to suppose that a similar report will be sent to the 'Observatory.' Now there are several inaccuracies in the printed report which I had pointed out at the meeting; but as my corrections do not appear, and the errors are still persisted in, I will ask you to allow me the space to repeat them.

First. It is uncharitable to assume that the most active promotors of the society relinquished their share in the work "when the novelty of their position settled down into routine." As a matter of fact, most arduous routine work was continued by them for 4 years without a break, and, after one year's relaxation, their names are again on the list of active workers.

Second. The annual subscription of 5*s*. has hitherto proved sufficient for the working expenses. The session of 1884–85, which Mr. Roberts is so hard on, was an exceptionally heavy one. I have taken some trouble to go into the accounts, and find that although 193 pages of printed matter, besides 42 illustrations, had been sent post-free to each member, the total amount of debts incurred did not exceed the income by more than £8. Even this small deficiency might have been avoided if the directors had not provided 160 bound volumes of the Journal for future contingencies.

Third. The annual meeting is not in October, but in July. At the last annual meeting it was proposed to defer it until October; but, as it was shown that this would on many accounts be inconvenient, the motion was lost.

Fourth. It has never been found necessary that active workers should reside in Liverpool. The great object of the society, and of the publications which are the life of the society, is to record the astronomical observations of its members, and Liverpool is perhaps least of all suitable for such work. The necessity for paid assistance is negatived by the fact that such men as Denning, Franks, Gore, Espin, Elger, and others have cheerfully volunteered regular literary and scientific work. Twice the present income of the Society would not suffice to pay for competent management; and, if the enthusiasm and devotion of the members should fail, mercenary assistance would avail but little.

Finally. It is a pity that Mr. Roberts should have troubled himself to prepare a report on the affairs of the Society at all. It is distinctly stated in bye-law 4 that this shall be the work of the *Council* *, and that the report shall be presented at the annual meeting. The object of this law is, plainly, to frustrate any attempt at influencing the general election of officers; and the closing part of Mr. Roberts' address shows only too clearly the necessity of such a provision.

W. H. Davies,
A Vice-Pres. of the L. A. S.

The Proposed Change in the Astronomical Day.

Gentlemen,—

Will the Editors of the 'Observatory' allow me to state my opinion on the so-called Astronomical Time? Two years ago I asked our *Bureau des Longitudes* what were its advantages. Our learned president, Mons. Faye, answered that he knew of none. Neither do I. It is passing odd to date May 7 merely because I have observed before noon on May 8. Have we not already enough kinds of time, whether mean, apparent, or sidereal, all necessary distinctions, and must we add astronomical time, which is quite artificial?

The other day I asked our two most eminent French astronomers what is their opinion on this vexed question. One of them answered that astronomical time is a cumbrous superfluity, but that when making a change he should advocate also the decimal division of angles on circles and clocks, thus getting rid of our useless distinction, in right ascensions, between time or space, and bettering three computing tools at once. My other colleague withheld his opinion, but informed me that when observing the Sun on the meridian, he took care to write two dates, because apparent noon is now before and then after mean noon, the latter being the standard. It therefore appears that astronomical time, though intended to simplify, actually introduces a complication. Your Astronomer Royal has done wisely in advising us to use only our familiar civil time. His position and authority entitle him to be our leader in a most welcome improvement.

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* "The Council shall draw up a Report on the state of the affairs of the Society, to be presented at the Inter-sessional General Meeting. In the Report shall be given an abstract of the proceedings during the preceding year."—*Bye-law* 4.

When Stephenson, another distinguished Englishman, introduced locomotives, carters and coachmen might have argued as follows:—"Our time-honoured ways are the safest and therefore decidedly the best. Long experience is in their favour; we form an overwhelming majority in the carrying line and ought to be respected; our most eminent waggoners disapprove your new-fangled proposals." In spite of their reluctance to be jerked out of hackneyed ruts, their feelings were discarded because progress means change, and because common sense must be preferred to current opinions, not always better from having lasted long.

I am afraid that some astronomers now reason unconsciously like those waggoners of old. Yet astronomy is inseparable from progress. Our tables of the solar system are changed for improvement several times in a century. It will be easy to adapt new ones to civil time, and until then computers of the 'Nautical Almanac' need not fear to stumble over new traps, for they enjoy their quiet homes, are up to the most intricate work, and astonish us by their ability to wade successfully through long calculations. As for old tables given in astronomical time, astronomers would find little difficulty in adapting their computations to the one simple rule of civil time. The latter would be a boon to amateur astronomers, who are a growing class nowadays, and seldom pretend to much knowledge in theory.

Sailors and travellers are far more numerous than astronomers, and deserve therefore to be cared for in this sore question. They have many other preoccupations, and being obliged to observe and compute off and on are more liable than professionals to make mistakes. When reducing hour-angles often dated in civil time they must calculate the Sun's declination and the equation of time while bearing in mind two different kinds of numbers, some increasing and others decreasing. Moreover they have to compute forward in the afternoon, but backward in the morning. This latter alternative would be avoided by dating all hours from midnight.

Astronomical work is chiefly done in darkness. When an observer begins at the first peep of stars in the evening he can seldom go on after midnight, for his energy is then overtaxed, and when computing he prefers that epoch as nearer to his favourite hours than the more distant time of noon. The Sun is the only pretext for beginning days at noon, *i. e.* after they have really begun. It is strange that this definition, this commencing what is already half over, should have been invented by mathematicians trained in geometry's strict logic. Its only excuse was when tables were so imperfect that daily observations of the Sun were necessary to ensure accuracy. Perhaps it might be convenient to head the Sun's pages in the N. A., one with the epoch at Greenwich apparent noon, and the other with that of Greenwich mean midnight, the latter being applied also to stars and planets, *i. e.* nearer to the time when they are observed.

While travelling in Africa, where a loss of date would have been a serious hindrance, I employed only civil time, and when training explorers I advised them to use no other. It has been my lot to reduce observations made by absent or deceased travellers whose ways were unknown to me, and I have sometimes been forced to make preliminary computations and investigate extraneous circumstances in order to find out what kind of time had been used. This is at least one of the inconveniences pertaining to the so-called astronomical time. For the sake of those who bow to authority, I may add that Laplace used only civil time in his 'Mécanique Céleste'; Damoiseau's lunar tables and perhaps some others followed that precedent. Can you tell me what astronomers complained of hitch or disadvantage when subsequent tables took up the beginning of day at noon? If the change was then bridged over easily, can we not do as much now?

Faithfully yours,

ANTOINE D'ABBADIE,

Paris, 1886, May 7 or 8. *de l'Institut et du Bureau des Longitudes.*

Brorsen's Comet (1846).

GENTLEMEN,—

From the known variations in the brilliancy of comets, the frequent missing of some of them on known returns, and the apparently final disappearance of others, it occurred to me that some of our small comets of short period may have been observed as larger comets in past times, and I have accordingly spent some time over the catalogue of comets in Chambers's 'Descriptive Astronomy' in attempting to detect them. Owing to the uncertainty of the elements determined by the earlier observations, and the fact that no date can be very far removed from some former perihelion passage of a comet of short period, it was not easy to arrive at satisfactory results, but in the case of Brorsen's comet of 1846 the coincidences are at all events of rather a striking character.

This comet passed its perihelion on the 25th of February, 1846, and its accepted period is, I believe, 5·581 years. Reckoning backwards, 33 revolutions would occupy 184·173 years, and would bring us to the end of December 1661 for the perihelion passage of the comet. Now on the 26th of January, 1661, a comet passed its perihelion whose elements thus compare with Brorsen's (as computed by Hind from observations in 1846):—

	π.		☊.		*i.*		*q.*	*μ.*
Brorsen's Comet of 1846...	116°	28′	102°	37′	30°	57′	0·65	Direct.
Comet of 1661..............	115	16	81	54	33	00	0·44	Direct.

Eleven months is not an inconsiderable difference in the case of a comet of such short period, and if the case rested there it would not be a strong one. But this comet of 1661 has been already identified by astronomers with that of 1532, and this fact at once affords another link in the chain of identification. The difference in time between the perihelion passages of the comets of 1532 and 1661 was 128·27 years, whereas Brorsen's comet completes 23 revolutions in 128·36 years. The slight difference brings the perihelion passage of the comet of 1532 nearer to that computed for Brorsen's comet than was the case with the comet of 1661.

Taking a further turn back of 79 revolutions of Brorsen's comet, we obtain a period of 440·90 years. But 440·66 years before the comet of 1532 passed its perihelion, another comet did so whose elements are as follows:—

	π.	☊.	i.	q.	μ.
Comet of 1092...	156° 20′	125° 40′	28° 55′	0·928	Direct.

The difference here brings the observed perihelion passage three months nearer to that computed for Brorsen's comet.

Once more I turn back 93 revolutions of Brorsen's comet. They occupy 519·03 years. But 517·87 years before, a comet passed its perihelion whose elements are:—

	π.	☊.	i.	q.	μ.
Comet of 574...	143° 39′	128° 17′	46° 31′	0·963	Direct.

A difference of 1·16 years in the perihelion passage is by no means incredible after 93 revolutions; but going back to 1846 and reckoning backwards 228 revolutions of the comet, the difference between the observed and computed time is less than with the comets of 1661 and 1532, while in no case does the difference amount to one year.

Assuming the identity of the four comets in question with that of Brorsen, and determining the periodic time of the latter by the average of 228 revolutions, we obtain 5·578 years instead of 5·581. If this is the true period, the intervals between the perihelion passages in 1092 and 1532, and between 1532 and 1661, were almost perfectly accurate, but the motion was slightly accelerated between 574 and 1092 and retarded to about the same extent between 1661 and 1846.

Truly yours,
W. H. S. Monck.

Dublin, 1886, May 1st.

P.S.—I subjoin two determinations of the elements of the comet of 1532 by Mechain and Halley respectively:—

	π.	☊.	i.	q.	μ.
Mechain	135° 44′	119° 8′	42° 27′	0·613	Direct.
Halley............	111 7	80 27	32 36	0·509	Direct.

The first of these determinations strongly resembles the comet of 574, the second the comet of 1661. ... ...

The Nature of the Red Spot on Jupiter and the relative Heights of Jovian Markings.

GENTLEMEN,—

Notwithstanding the length of time during which the red spot on Jupiter has been visible, now amounting to at least 8 or 9 years, and the fact that, during this period, it has been subjected to a most searching and continuous scrutiny by a multitude of observers, furnished with instruments varying from a small size up to some of the largest and finest in the world, the real nature and constitution of this remarkable feature remains completely unknown to us. We have no certain knowledge whether it is attached to, and forms part of, the surface of the planet, or whether it is suspended in the atmosphere of Jupiter. Some observations which have been recently published appear capable, however, of throwing some light upon these unknown particulars, at all events upon the last of them, and hence a few remarks upon these and the evidence they appear to afford upon a subject of such importance may not be out of place.

In the 'Observatory' for May, p. 188 *et seq.*, Mr. Denning has given an elaborate and interesting account of the present state of the visible surface of the planet about the place of the red spot. An important peculiarity consists in the circumstance that the red spot appeared to overlap, and be projected upon, the dusky belt lying immediately south of it; and this peculiarity is attested by three observers (Messrs. Denning, Perry, and Tarrant), all provided with telescopes of considerable size, so that there would be good reason for believing it to be an actual fact. If this be so, it is probably the most important piece of evidence which we have yet succeeded in obtaining as to the altitude of this object. It would indicate that not only is the outer surface of the spot situate at a considerable elevation above the surface of Jupiter, but also that it is not continued right down to the surface or crust of the planet, as otherwise the dark belt could not be seen to disappear behind one side of the red spot and reappear at the other side in an unaltered condition, as is shown in Mr. Denning's drawing of the planet on p. 189. But if we have to assume this to be the case, it becomes really a difficult matter to imagine how an object, such as the red spot, could remain suspended at some height in the Jovian atmosphere, and maintain for such a length of time its characteristic features, since it is natural to consider that in such a case it would be chiefly vaporous in its constitution. This circumstance constitutes, in fact, such a considerable obstacle, that it is natural to look with some distrust upon the observations tending in favour of it. I wish therefore to call attention to the *great desirability* of further observations upon this important subject, since it appears probable that, in the present happy situations of the markings, we may learn more in a short time about the actual circumstances of the red spot than we have been able to do during the many years in which it has been visible.

It has been frequently pointed out that the dusky material constituting the belts and markings just south of the red spot is endowed with a slow motion from right to left as compared with the latter object, and this circumstance should enable a decision to be made, with some degree of certainty and ease, as to the relative altitudes of the red spot and the dark belt; and there are three principal appearances which should be carefully looked for with this view, namely:—1. If the south border of the red spot remains quite distinct, and no darker than the north border, whilst the dusky belt seems to pass behind it without distortion and unaffected, it may be inferred that the former object is suspended above the latter. 2. If the southern side of the red spot is darkened, and its outline becomes at all indistinct, whilst the dark belt appears unaltered, it is probable that the belt is at a higher level than the spot. 3. If the dusky belt is distorted, and especially if the dark material composing it is deflected and exhibits a tendency to crowd about the southern and south-following edge of the red spot, there will be reason for believing that the substance of the latter extends both above and below the belt, and probably to the surface of the planet, and causes the material of the belt to be diverted, in the same way that an island or cape turns aside a current of water.

That the outer surface of the red spot should be much more elevated than other markings is of course neither impossible nor improbable. The difficulty is in conceiving it to be floating in the atmosphere and yet unconnected with the surface of the planet, as the recent observations would seem to imply.

In the 'Observatory' for January 1883, p. 20, and elsewhere, I have given reasons for considering that the dark matter of the south equatoreal belt is situate at a higher altitude than the white equatoreal spots and markings that lie adjacent to this belt. Additional evidence of the correctness of this view is afforded in the "Note on Observations of Jupiter" by Dr. L. de Ball, in the 'Observatory' for May last, p. 207, in which it is stated that—"A bright train ran along a part of this belt, and intersected the two most easterly of the dark spots; but the bright matter could still be traced through the material of the dark spots."

Yours faithfully,

West Brighton, 1886, May 22. A. STANLEY WILLIAMS.

Eclipse of Jupiter's Fourth Satellite, 1886, *April* 30.

GENTLEMEN,—

In the Ephemeris for Physical Observations of Jupiter ('Monthly Notices,' Vol. xlv. no. 9), Mr. A. Marth directed the attention of observers to the importance of securing accurate observations of "some of the last eclipses of the present cycle of eclipses of the fourth satellite." The eclipse of April 30 was observed here with the utmost care, and the night proved to be exceedingly favourable for good results. The brightness of the satellite began to diminish long before the total obscuration. I watched it for more than half an hour, and it was much obscured when I began. The rate of obscuration was *so slow*, that it was exceedingly difficult to decide on the moment of total disappearance. At least two times were noted at which it was thought disappearance had occurred, but a second or two *later* the satellite was still seen. At the reappearance my eye was intently strained on a point a little too *low* in the field, and probably a few seconds were lost, the "minimum visible" having occurred a little earlier; but as the light of the satellite *increased* much faster at the reappearance than its rate of obscuration had been at the disappearance, this error, if any, could be but a few seconds. The observations were made with a power of 300; and the planet was turned entirely out of the field by the slide, so that the field of the satellite was free from glare. The times were accurately noted on the chronograph, and are given, not only for the Local Meridian, but for the Meridians of Washington and Greenwich, to show the acceleration and retardation of the *observed* times on the computed times of the American and British Nautical Almanacs. Having had a large experience in observing occultutions and eclipses of these satellites, I think the observations are as accurate as can be expected without the aid of photometric appliances.

	Loc. M.T.	W.M.T.	G.M.T.
	h m s	h m s	h m s
Observed time of Disappearance...	11 3 51·04	12 6 56·97	17 15 9·07
Computed " " ...		12 14 15·80	17 20 16·00
Acceleration		7 18·83	5 6·93
Observed time of Reappearance ...	11 30 21·19	12 33 27·12	17 41 39·22
Computed " " ...		12 24 11·00	17 37 8·00
Retardation		7 16·12	4 31·22

Yours respectfully,
C. W. Pritchett.

Morrison Observatory,
May 1886.

The Star in the Nucleus of the Andromeda Nebula.

Gentlemen,—

In No. 109 of the 'Observatory' Mr. Espin has some observations and notes on the Nova and Nucleus of the Andromeda Nebula. My own observations, made in September, October, and November, fully confirm the statements of Mr. Espin as to the stellar characteristics of the nucleus. I use the term nucleus, as I find it used by others; but I am certain that what is called the nucleus is only a haze-enveloped star. I became satisfied of this on Sept. 13, when the stellar character of the object was not only recognized by myself, but was pointed out to others and recognized by them. On numerous occasions during the autumn and early winter this conclusion was abundantly confirmed. The utmost pains was taken to avoid the mistake of a *secondary* image by changing and turning the eyepieces. I wrote to Mr. Burnham, asking him to examine it with the large refractor of the Dearborn Observatory; but he informs me that he only looked to see if the Nova itself might be a close double, and did not search for any thing at all removed. I see no reason why the Nova should not be considered as having a faint companion about 12″ or 15″ off, and nearly following it. The magnitude of the companion was certainly above 12. I cannot but think that both the Nova and this companion are involved in the nebula itself, and are not *interposed*. I may add that I began to observe the Nova on Sept. 1, and that it was *then* brighter than at any subsequent time. My estimation of it *then* was 7 of Argelander's scale.

Yours respectfully,
C. W. PRITCHETT.

Morrison Observatory,
Glasgow, Mo., U.S.A.

The Binary Star γ Coronæ Australis.

GENTLEMEN,—

In accordance with a request by Mr. Downing, I transmit the following unpublished observations of the binary star γ *Coronæ Borealis*. They were made with the 11-inch equatoreal of the Cincinnati Observatory, with a filar micrometer, bright wires in a dark field, and magnifying-power 450. The eyes of the observer were placed either parallel or normal to the line joining the centres of the stars.

Epoch.	Position-angle.		Distance.		Eyes.	Observer.
	Obs.	Corr.	Obs.	Corr.		
	°	°	″	″		
1881·719	45·0	45·5	..	..	*n*	O. Stone.
·721	46·1	46·8	1·41	1·41	*p*	”
·721	43·8	44·3	1·43	1·35	*n*	”
1883·565	39·0	37·3	1·5 est.	..	*p*	H. C. Wilson.
·565	37·4	38·7	..	..	*n*	”
·675	35·2	36·5	1·66	1·62	*n*	”
·675	40·2	38·5	..	..	*p*	”

The corrections applied to the first three measures were taken from Professor Stone's investigation (Publications Cincinnati Observatory, No. 5), those to my own measures from an unpublished investigation of my personal errors during the period from 1882 to 1886. The mean results for the two epochs are:—

1881·72 .... 45°·53 .... 1″·38
1883·62 .... 37 ·75 .... 1 ·62

The latter epoch is near the time of periastron passage according to Mr. Downing's elements ('Monthly Notices,' vol. xliii. page

370), but the measures differ considerably from the required position-angle and distance.

To compare the observations with Mr. Gore's elements ('Monthly Notices,' Jan. 1886), I computed the position-angle and distance for the two epochs by means of his formulæ, obtaining the following results:—

1881·72 .... 227°·29 .... 1″·36
1883·62 .... 216 ·49 .... 1 ·29

which may be regarded as agreeing fairly with the observations. The difference between the distances for the last epoch is considerably larger than my probable error for a single measure; but this may, perhaps, be accounted for by the low altitude and consequent blurring of the stars.

Very respectfully,
H. C. Wilson,
Assistant Astronomer.

Cincinnati Observatory,
1886, April 12.

Last Eclipse of Jupiter's IVth Satellite.

Gentlemen,—

As observations of both the immersion and emersion of the IVth sat. are not very common, and as they are of some interest near the end of a series, I may mention that the duration of that on March 11 seemed considerably lengthened beyond the calculated time.

Last visibility .... 10^{h} 34^{m} 57^{s}
First ,, ... 12 39 27

I observed with a power of 180 on a 3¼-inch Cooke. Unfortunately the state of the atmosphere prevented observation of the eclipse of this satellite expected by Mr. Marth last night.

Faithfully yours,
S. J. Johnson.

Melplash Vicarage, Bridport,
1886, May 18.

NOTES.

The Observatory of Yale College.—We have received the Report on the work done at this Observatory during the year ending June 1, 1885. The officers in charge of the different departments are:—Dr. L. Waldo, in charge of the Horological Bureau; Mr. O. T. Sherman, in charge of the Thermometric Bureau; and Dr. W. L. Elkin, in charge of the Heliometer. The system of watch-trials, carried out under Dr. Waldo's superintendence, agrees generally with the scheme adopted at the Kew and Geneva Observatories. The experiments relating to the establishment of a clock of precision for watch-rating purposes have been continued by Dr. Waldo during the year, and the results of the experience thus gained are being embodied in the new clocks now approaching completion at the works of one of the leading clock companies. In addition to the special work of his department, Mr. Sherman has made some measures of the diameter of Venus with a Grubb filar micrometer attached to the 8-inch equatoreal. The resulting mean value of the diameter is 17″·3, with 1″·8 for the value of the constant depending on personality, thickness of wire, &c. Mr. Sherman also finds that the diameter measured with 8-inch aperture is greater than the diameter with 6-inch aperture by 0″·22, and greater than the diameter with 4-inch aperture by 0″·27. The principal object of research with the heliometer has been the triangulation of the Pleiades. It was originally intended to confine the investigation to the stars measured at Konigsberg, and to carry out only one method of triangulation. The scheme has been extended, however, to include all the stars in the Bonn 'Durchmusterung,' within certain limits, down to the mag. 9·2, making 69 stars in all, and also to obtain a determination of the relative positions of the stars which should be strictly comparable with the Königsberg work, viz. measurements of distances and angles of position of the stars from Alcyone. The final reduction of the observations, cannot be undertaken until the results of the meridian observations of the stars serving to determine the scale value and zero of position have been received from the observatories which have consented to make them. It is now proposed to devote the heliometer to systematic investigations in stellar parallax, and a plan of work has been laid out and commenced, which, if carried to completion, will furnish, it is hoped, a reliable value of the relative parallax of the stars of the first and eighth magnitudes.

NOTES ON VARIABLE STARS.—The Rev. T. E. Espin, B.A., observer to the Liverpool Astronomical Society, has issued circulars to the following effect:—

Circular No. 1.—10 Sagittæ. Observations obtained April 26 to May 3 show an error in the period of $-0^{\mathrm{d}}\cdot261$. The following elements and ephemeris have been deduced:—P=8·317; V=5·6–6·4–; Epoch M = April 24·806 ($m = M + 5^{\mathrm{d}}\cdot7 \pm$). Maxima, June $5^{\mathrm{d}}\cdot4$; $13^{\mathrm{d}}\cdot7$; $22^{\mathrm{d}}\cdot0$; $30^{\mathrm{d}}\cdot3$. Minima, June $2^{\mathrm{d}}\cdot7$; $11^{\mathrm{d}}\cdot1$; $13^{\mathrm{d}}\cdot8$; $27^{\mathrm{d}}\cdot7$. The fluctuations in light are very interesting and easily seen.

Circular No. 2.—D.M + 8° No. 3780, mag. 8·6. Probably variable. Observed as 7·7 on April 26; colour fine red; 7·5 on April 29; and 7·0 on April 30. R.A. (1885·0) $18^{\mathrm{h}}\ 32^{\mathrm{m}}\ 51^{\mathrm{s}}$, Dec. + 8° 43′·5.

Circular No. 3.—U Hydræ. R.A. $10^{\mathrm{h}}\ 31^{\mathrm{m}}\cdot9$, Dec. −12° 40′·7. The following provisional elements have been deduced from the observations of the last six years:—P=$194^{\mathrm{d}}\cdot65$; V=+5·0, 5·2–6·1, 6·3–; Epoch M=1885, Dec. 11·73 ($m = M + 107^{\mathrm{d}} \pm$).

THE PARALLAX OF ψ^5 AURIGÆ *.—The parallax of this double star has been deduced by Herr Schur from observations of position-angle and distance made by him with the 6-inch refractor of the Strassburg Observatory on 30 evenings, between January 14, 1883, and January 29, 1885. The observed position-angles and distances having been transformed into $\Delta\alpha \cos \delta$ and $\Delta\delta$, Herr Schur finds (taking the proper motions of the brighter star from Auwers' Fundamental Catalogue)—

from differences of R.A. $\pi = +0''{\cdot}126 \pm 0''{\cdot}036$
from differences of Decl. $\pi = -0''{\cdot}009 \pm 0''{\cdot}094$
and combining these, $\pi = +0''{\cdot}111 \pm 0''{\cdot}034$.

This value refers to the fainter star of the pair (of the 9th mag., the brighter star being 6th mag.), the place of this star having been referred to that of the brighter one in the observations.

ECLIPSE OF JUPITER'S FOURTH SATELLITE.—Mr. John Tebbutt sends us, in the 'Sydney Morning Herald' for April 1, an account of his observation of the eclipse of the fourth satellite of Jupiter which occurred on March 28. Mr. Tebbutt had previously drawn the attention of Australian astronomers to this eclipse and the one on April 14, as they were the last of the series just terminated which were visible in Australia, and as such were specially valuable on account of the way in which a slight error in the latitude of the satellite reveals itself in the duration of the eclipse. Mr. Tebbutt's recorded times were:—Disappearance, $14^h\ 38^m\ 34^s$ Windsor Mean Time; Reappearance, $16^h\ 28^m\ 6^s$. The disappearance was therefore $15^m\ 43^s$ before the predicted 'Nautical Almanac' time, and the reappearance $8^m\ 55^s$ after it. Mr. Tebbutt fancied that he caught a glimpse of the satellite 48^s after the time he at first noted as that of disappearance; but, on the other hand, Mr. Russell, at Sydney, setting his telescope on Jupiter 23^m before the predicted time of disappearance, was unable to see the satellite, which apparently had already vanished. His observation of the reappearance was in fair accord with Mr. Tebbutt's.

THE MADRAS OBSERVATORY.—The Report of the Government Astronomer for the year 1884 has recently been received. Mr. Pogson refers with satisfaction to the publication of "Telegraphic Longitude Determinations in India" ('Observatory,' Vol. viii. p. 396) which was printed and ready for issue before the end of the year. The number of observations made with the meridian circle during the year was 844. The total number of observations made with this instrument since 1862, awaiting publication, now amounts to 51,722. The separate results and annual catalogues will fill eight volumes, to be followed by a final catalogue of about 5000 stars reduced to the epoch 1875; and as all reductions are completed up to date, Mr. Pogson hopes that these publications will appear in fairly rapid succession. We sincerely hope that Mr. Pogson will

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* Astron. Nachrichten, No. 2723.

be enabled to publish these volumes before the close of his official career, as no volume of Madras astronomical observations has been issued since his appointment in 1860. With the equatoreals observations of minor planets and of comets have been made. The total eclipse of the Moon on October 4 was also observed, three disappearances and six reappearances of stars from Prof. Struve's list having been observed during totality.

A new Astronomical Review.—We have received the first four numbers of a new monthly astronomical review entitled 'Revista do Observatorio,' and published by the Imperial Observatory of Rio de Janeiro. We cordially welcome this new publication, which will doubtless render no small service to our science. If our *confrères* of the Brazilian observatory can call forth an increased interest in astronomy in the South American continent, we may hope for the happiest results—the field for southern observers is so rich and so wide, the labourers so few.

The new periodical certainly promises well; each number contains 16 well-printed imperial 8vo pages, and a plate showing the position of the principal stars as seen from Rio de Janeiro at 8^h sidereal time. The January number contains a letter of welcome from M. Flammarion, written in his most characteristic style. The February number, now before us, has the following articles and notes:—Mnemonic method for facilitating the deduction of the formulæ of Delambre and Napier; the temporary star of the Andromeda Nebula; Rapid motion of certain Stars; mass of the planets Uranus and Neptune; observations of Comet Barnard; the Sun-spot period. Reviews of the following publications:—Mr. Sandford Fleming's paper on the establishment of a universal prime meridian, published by the Canadian Institute; Report of the International Meteorological Committee, Upsala, 1885; Dr. Dunér on Third type Spectra. The Aspect of the Heavens during March. Meteorological observations made at the Imperial Observatory during Jan. 1886. Notes on the following subjects:—Mr. Gore's Nova Orionis; the magnitude of Neptune; the Great Pulkowa equatoreal; discovery of the Maia nebula by photography; recently discovered minor planets; the Almucantar of Mr. Chandler. The name of the latter is, however, misspelled as Chambers.

We trust the 'Revista' will not fail to meet with the complete success which its projectors are evidently determined it shall deserve.

Discovery of Comet Brooks 3.—Mr. W. H. Brooks discovered a third comet on May 22. The following observations of it have come to hand:—Harvard, May 23, 15^h G.M.T.: R.A. $11^h\ 55^m\ 12^s$; Dec. $+8^\circ\ 55'$. Albany, May 25, $17^h\ 8^m$ G.M.T.: R.A. $11^h\ 54^m\ 45^s{\cdot}4$; Dec. $+7^\circ\ 40'\ 46''$.

A new Minor Planet, No. 258, mag. 11, was discovered by Prof. R. Luther at Dusseldorf on May 7.

*Ephemeris for Comet Fabry**.

By Dr. S. OPPENHEIM.

For Berlin Midnight.

1886.	R.A. h	m	s	Dec. °	′	Log *r*.	Log Δ.	Brightness.
une 4..	8	42	45	−40	17·9	0·1243	0·0003	7·2
8..	8	50	32	40	52·6	0·1437	0·0426	5·4
12..	8	57	40	41	24·1	0·1621	0·0804	4·2
16..	9	4	19	41	55·1	0·1797	0·1147	3·3
20..	9	10	37	42	25·4	0·1966	0·1460	2·6
24..	9	16	41	42	56·7	0·2127	0·1747	2·1
28..	9	22	35	43	28·3	0·2282	0·2012	1·8
July 2..	9	28	20	−44	0·8	0·2430	0·2258	1·5

The brightness on 1885 Dec. 1 is taken as unity.

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*Ephemeris for Comet Barnard**.

By Dr. J. v. HEPPERGER.

For Berlin Midnight.

1886.	R.A. h	m	s	Dec. °	′	Log *r*.	Log Δ.	Brightness.
June 3..	5	39	13	−33	56·4	9·9383	9·6144	169
7..	6	22	56	41	24·9	9·9720	9·6908	102
11..	6	59	30	45	51·2	0·0034	9·7644	63
15..	7	29	25	48	32·5	0·0326	9·8308	40
19..	7	53	57	50	15·1	0·0598	9·8898	27
23..	8	14	22	51	25·0	0·0852	9·9421	19
27..	8	31	42	52	16·2	0·1089	9·9887	14
July 1..	8	46	44	−52	56·9	0·1312	0·0306	10

The brightness on 1885 Dec. 6 is taken as unity.

Elements and Ephemeris for Comet Brooks 1†.

By Dr. H. OPPENHEIM.

THE following elements for the comet discovered by Mr. W. H. Brooks on Apr. 27 are derived from observations made at Rome on Apr. 29, at Kiel on May 4, and at Hamburg on May 9.

T=1886 June 7·7066 Berlin M.T.

$$\left.\begin{array}{lr} \omega \ldots\ldots\ldots\ldots & 199^\circ\ 59'\ 35'' \\ \text{☊} \ldots\ldots\ldots\ldots & 193\ \ 23\ \ 46 \\ i \ldots\ldots\ldots\ldots & 87\ \ 50\ \ 54 \end{array}\right\}\text{ Mean Eq. 1886·0.}$$

$$\text{Log } q = 9{\cdot}44812.$$

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* Astron. Nachr. No. 2723.

† Dun-Echt Circular, No. 120.

Ephemeris for Berlin Midnight.

1886.	R.A. h m s	Dec. ° ′	Log *r*.	Log Δ.	Brightness.
June 2..	3 44 19	+26 18·8	9·5138	0·0792	13·4
4..	3 55 55	22 39·2			
6..	4 9 8	18 52·0	9·4523	0·0691	18·6
8..	4 24 12	15 6·3			
10..	4 41 0	11 31·8	9·4695	0·0571	18·2
14..	5 18 10	+ 5 19·2	9·5490	0·0481	13·1

The brightness at the time of discovery is taken as unity.

Elements and Ephemeris for Comet Brooks 2.

Mr. W. H. Brooks discovered another bright comet on April 30, three days after his discovery of the first. This second comet was very bright at the time of discovery, being near its perihelion; it is now becoming steadily fainter day by day. Baron von Engelhardt * describes it as having on May 3 a circular nucleus, with an offshoot 2′ in length in the direction of the axis of the tail. The tail was 8′ long and very bright, narrow at first, but growing broader further from the nucleus. It was bent with the convex side to the north. A secondary tail 6′ in length, split off from the principal tail 6′ from the nucleus; this secondary tail lay towards the south and was only faint.

Prof. C. Frisby † has computed the following elements and ephemeris from observations made by himself on May 2, 3, and 4:—

$T = 1886$ May 4·540 Greenwich M.T.

$$\left.\begin{array}{ll}\pi-\Omega \ \ldots\ldots & 38^\circ\ 45'.5\\ \Omega \ \ldots\ldots\ldots & 287\ \ 57\ .2\\ i \ \ldots\ldots\ldots & 100\ \ 57\ .4\end{array}\right\}\text{App. Equinox.}$$

$\log q \ldots\ldots$ 9·92551

Ephemeris for Greenwich Midnight.

1886.	R.A. h m s	Dec. ° ′	Log *r*.	Log Δ.	Brightness.
June 3..	4 41 53	+71 31·8	0·0032	0·1193	0·40
7..	5 39 24	70 35·1	0·0204	0·1478	0·32
11..	6 23 20	69 15·0	0·0380	0·1783	0·26
15..	6 58 55	66 54·1	0·0557	0·2015	0·21
19..	7 27 41	64 28·3	0·0734	0·2275	0·17
23..	7 39 51	62 58·9	0·0909	0·2486	0·14
27..	7 59 37	+60 49·5	0·1081	0·2704	0·12

The brightness on May 2 is taken as unity.

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* Astron. Nachr. No. 2728.

† 'Science Observer,' Special Circular, No. 67.

JULY, 1886. [*Price* 1s.

E OBSERVATORY,

MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
he Royal Astronomical Society on June 11 241

tes. By W. F. Denning, F.R.A.S. 254

dence:—

nclature of the Constellations near the South Pole. By W. T. Lynn,
F.R.A.S. 255
ty of Algol. By J. E. Gore, M.R.I.A. 257
ed Change in the Astronomical Day. By Capt. W. Noble, F.R.A.S. 258
Visits of Periodic Comets. By W. H. S. Monck, M.A., F.R.A.S. ... 259

ervatory, Greenwich.—The University Observatory, Oxford.—
Flexure of Meridian Instruments.—Universal, or World Time.—
Melbourne Observatory.—The East Anglian Earthquake of
—The Paris Observatory.—Publications of the Zone Observations
Astronomische Gesellschaft.—The Influence of Phase on the
tness of the Minor Planets.—The Absorption Spectrum of Oxygen.
es on Variable Stars.—Proper Motion of Lalande 27026.—A Cor-
n.—Minor Planet.—Editorial Note 260–272

Comet Brooks 1. By Dr. A. Berberich 272
Ephemeris for Comet Brooks 3. By Dr. S. Oppenheim 272

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and T. LEWIS, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpool Ast
nomical Societies; Articles by various eminent Astronomers, Engli
American, and Continental; Correspondence on topics of interest connect
with the Science; Notes on the progress of Astronomy; Reviews of ast
nomical publications; Ephemerides of comets, variable stars, Satur
satellites, and for physical observations of the Sun, Jupiter, &c.; and
the usual astronomical information.

Amongst the contributors to 'The Observatory' in 1885 were Profess
Asaph Hall, Holden, Hough, Pickering, Pritchard, and Young;
Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs. Barna
Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"—*Bull*
Astronomique (organ of the Paris Observatory).

CONTENTS OF No. 111.

Meeting of the Royal Astronomical Society on May 14 2
Meeting of the Liverpool Astronomical Society 22

Articles:—

The Density of the Sun compared with that of Algol. By MAXWELL HALL, M.A., F.R.A.S. 22

Correspondence:—

The Liverpool Astronomical Society. By W. H. DAVIES, F.R.A.S. 22
The Proposed Change in the Astronomical Day. By ANTOINE D'ABBADIE 22
Brorsen's Comet (1846). By W. H. S. MONCK, M.A., F.R.A.S. 22
The Nature of the Red Spot on Jupiter and the relative Heights of Jovian Markings. By A. STANLEY WILLIAMS, F.R.A.S. 23
Eclipse of Jupiter's Fourth Satellite, 1886, April 30. By Prof. C. W. PRITCHETT 23
The Star in the Nucleus of the Andromeda Nebula. By Prof. C. W. PRITCHETT 23
The Binary Star γ Coronæ Australis. By H. C. WILSON 23
Last Eclipse of Jupiter's IVth Satellite. By the Rev. S. J. JOHNSON, F.R.A.S. 23

Notes:—

The Observatory of Yale College.—Notes on Variable Stars.—The Parallax of ψ^5 Aurigæ.—Eclipse of Jupiter's Fourth Satellite.—The Madras Observatory.—A new Astronomical Review.—Discovery of Comet Brooks 3.—A new Minor Planet 235-23

Ephemeris for Comet Fabry. By Dr. H. OPPENHEIM 23
Ephemeris for Comet Barnard. By Dr. J. v. HEPPERGER 23
Elements and Ephemeris for Comet Brooks 1. By Dr. H. OPPENHEIM 23
Elements and Ephemeris for Comet Brooks 2 24

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 112. JULY. 1886.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, June 11, 1886.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel, and
Lieut.-Col. G. L. Tupman.

The Minutes of the previous Meeting were read and confirmed.

Col. Tupman announced the receipt of sixty-three presents since the last Meeting. Calling for special mention was a volume of the German Zone Observations +75° and +80° from the Kazan Observatory.

Mr. Knobel. I have to announce the pleasing fact that the Catalogue of our Library is completed. It has been in preparation for two years, and what merit it possesses is entirely due to the energy and skill of our Assistant-Secretary, Mr. Wesley. It is a matter for congratulation that the Society has a Secretary capable of preparing a catalogue in so efficient a manner.

Mr. Beck. Is the Catalogue to be presented to the Fellows?

Mr. Knobel. The expense has been so great that the Council have resolved to charge the nominal price of 2*s.* 6*d.* for it.

Mr. Beck thought that as the cost was only half-a-crown it might as well be presented.

Capt. Noble explained that the charge to the general public was to be 10*s.*

Mr. Plummer read a paper by *Prof. Pritchard* on some photometric observations of fifty selected stars near the Equator. The object sought to be fulfilled by this selection differed from that of the American astronomers in their similar selection. In their case they only wished to be able to identify with rapidity and certainty all sections of the sky. Prof. Pritchard's object was to afford a ans of connecting northern and southern photometry, and also, the altitude of Polaris is such in these latitudes that it is not always convenient to compare stars with it so as to avoid correction for the atmospheric absorption, to provide a number of comparison stars all round the equator, with some of which it would be always possible to secure comparisons at about equal altitudes, thus doing away with the necessity for correcting for the absorption of the atmosphere. It was satisfactory to find that the great proportion of the stars, which had now been observed some sixty or seventy times, differed very little in the main from the magnitudes assigned to them in the Oxford Uranometria. Prof. Pritchard also stated in the paper that he had studied at the Oxford University Observatory the application of photography to stellar photometry with considerable success, and he believed that, properly applied, the method was pre-eminently adapted for the photometry of the fainter stars, those below the 7th magnitude. The following formula showed the relation between the photographic diameters of stars taken on the same plate and their magnitudes:—

$$D - D' = \kappa(\log \mu' - \log \mu);$$

the difference of the diameters varied as the difference of the logarithms of the magnitudes. Too high a power, however, should not be used in measuring the photographs.

Mr. Plummer also read a second paper by *Prof. Pritchard* on a remarkable condition he had twice observed in stellar photographs. The case in question referred to the stars near 61 Cygni. The plates had usually been exposed not more than five minutes, the object being to limit the diameter of the stellar disks to the smallest dimensions. With a much longer exposure the two components of 61 Cygni would probably coalesce. Eight plates had been taken on four nights, and on each plate the distances between the stars A and B and between C and D had been measured. The measures as regarded seven of the plates were in very satisfactory accord, the probable error not exceeding $\frac{1}{10}$ of a second. But the film on the eighth had been disturbed in the neighbourhood of the stars A, B, and C, and unaffected in other parts; the fact of the disturbance had not only been proved by the measures, but actually localized. From these results he thought they might fairly deduce the trustworthiness of the process as a whole, both as regards the ultimate determination of stellar parallax and as to the character of the photographic film.

Capt. Noble asked if red and blue stars which disappear at the same instant by the method of extinction would show disks of the same diameter on the photographic plate?

Mr. Plummer replied that, so far as the observations had yet been carried, red stars gave somewhat smaller disks in proportion than blue stars. He did not know whether Capt. Noble would call Pleione a blue star, but it gave a larger disk in proportion to its magnitude than any other star in the Pleiades. The measurements had been generally confined to the Pleiades, as that group contained the largest number of stars the photometric magnitude of which was known.

Mr. Ranyard thought the formula could only be approximate, as the radiation fringes would affect the measurements of the diameters of the star-disks in the photographs.

Mr. Plummer said that at Oxford they had only measured stars down to the 9th or 10th magnitude, and there might be a difficulty in carrying the method further. Their instruments were unfortunately not large enough to enable them to photograph beyond the 12th or 13th magnitude. They had, however, some photographs by the Bros. Henry, and they hoped to be able to ascertain from measuring those how far the formula could be used. Their measurements had been confined to the nucleus of the star, and in the double-image micrometer the power used was not high, and the fringe was actually lost.

Mr. Common stated that he had suggested to Prof. Pritchard that in photographing faint stars near a bright one, as in the case of 61 Cygni or α Lyræ, or any other stars it was proposed to photograph for the purpose of determining their parallax, the bright central star might be covered by a screen for part of the time that the plate was exposed. Thus, without such a device, in photographing Jupiter the planet was greatly over-exposed and the satellites much under-exposed; but with it, both planet and satellites could be obtained of their proportionate diameters. And with stars, the bright star might be covered so long that its image should be only a small point and therefore easily measured.

The President suggested the postponement of the discussion, that the Meeting might have the opportunity of hearing M. Cornu, whom they had the pleasure of seeing there that night. M. Cornu could unfortunately only remain a few moments, so he would call on him at once to give an account of the researches he had made bearing on astronomy.

M. Cornu, who was greeted with much applause, said:—Will you allow me to present to the Society two papers of mine? The first is on a method of distinguishing between those lines in the solar spectrum which are due to the absorption of the solar atmosphere, and those which are due to the absorption of our own atmosphere. It has been necessary hitherto to observe the spectrum when the Sun is very high in the heavens, and again when it is near the horizon; and those lines which showed a considerable difference of depth and density under the two different conditions were the telluric lines. But this method was very tedious; it could only be employed in very clear weather, and the observations had to be repeated again and again. By my method, on the contrary, it is possible to tell if any line be telluric or solar by simple inspection. A spectroscope of great dispersion is requisite, and an image of the Sun's disk is thrown upon the slit, so that one end of the Sun's equator falls on the slit. Then the opposite end of the equator is quickly brought upon the slit, the movement being easily effected without moving the spectroscope by means of a small reflector. As the one limb of the Sun is approaching us and the other receding, there is a real difference of wave-length in the same radiation as obtained from the two limbs; the wave-length, for instance, of the D line is slightly greater from the west limb than from the east. As the lines are arranged in the spectrum according to their wave-length, the shortest difference is shown by a little oscillation of the line. The method is a very simple one, it is as if you shook the spectrum; and if a line were a solar one it moved, if a terrestrial one it remained steady. The other paper which I have the honour to lay before the Society concerns the lines of a good many metals in the spectrum and with their arrangement and appearance. I have found exactly the same distribution of lines as Dr. Huggins discovered in his photographs of the spectra of the white stars. Those dark lines have been identified as belonging to the spectrum of hydrogen, and the same law of distribution has been recognized in the spectra of a great number of the metals—for instance, aluminium, thallium, zinc, and manganese. The lines are arranged in the same manner not only as to the distances between them, but also as to their intensity, which always diminishes with the wave-length. These lines are likewise characterized by a singular property: they are self-reversing in the spectrum; that is to say, that if a small piece of such a metal be placed upon the carbon of an arc-light, so that there is a small quantity of vapour, the metallic lines are seen as bright lines; but if the quantity of metallic vapour be greatly increased you obtain a continuous spectrum, and the metallic lines are seen reversed, and have exactly the appearance of the black lines discovered by Dr. Huggins in the spectra of the white stars. (Applause.)

A cordial vote of thanks was passed unanimously to M. Cornu for his communication.

Resuming the discussion on Prof. Pritchard's paper, *Mr. Stone* wished to know how these magnitudes had been obtained, by the absorption-photometer, or were they eye-estimations? He considered there was an essential difference between the two processes. He supposed that in eye-estimations, even with the method of limiting apertures, the brightness of the stars was judged from the total effects of the light condensed by the object-glass; but that was not the case with absorption-photometry. Leaving out of consideration the light dispersed over the diffraction rings, the central disk of the star offered an appreciable area, but the whole light was not concentrated in the central portion of the disk. Some years ago he had computed the intensity of the illumination of a star-disk by dividing it into twenty concentric rings of equal breadth, and he had found that the illumination of the central part of the disk was only about $\frac{1}{14}$ or $\frac{1}{15}$ part of the total amount of light in the disk. It seemed to him therefore an important matter to consider what was the effective portion of the light condensed by the object-glass which was measured by means of the photometer.

Mr. Common. What photometer?

Mr. Stone. Any method of extinction. I am not referring now to Prof. Pritchard's method in particular. The difficulty I see is this: In using the extinction-method first the light is lost which falls on one portion of the star-disk, then the light falling upon another portion, and lastly the impression of light is lost at some angular separation from the centre of the disk; but we cannot say how the vanishing point with different intensities is fixed; but certainly it is neither the whole light of the star which is effective, nor is it the light from a mere mathematical point. But whilst the whole amount of this light is not effective upon the eye through the absorbing medium, it is, I suppose, all effective upon the photographic plate. I think therefore that the formula Prof. Pritchard has given can only be approximate, and that there would be a difference between the formula established by the absorbing apparatus and by the eye itself. Similarly, I think, there would be a difference in the estimation of magnitude by the method of limiting apertures; for in these rings into which I have divided the star-disk, whilst the intensity of illumination at any one point decreases as you proceed outward, the area over which the illumination is distributed increases, so that the total effect of the light distributed over that area bears a very large proportion indeed to the light condensed in the central portion.

In reply to a question from *Mr. Common*, *Mr. Stone* thought that in absorption photometry no one knew with what portion of the disk we were dealing at the vanishing point. It was not possible to judge of the brightness of an absolute point, and we certainly did not deal with the whole disk.

In reply to *Mr. Ranyard*, *Mr. Stone* said that he had computed the illumination of the different portions of the star-disk strictly, in the way in which it is calculated in physical optics.

To a question by *Mr. Turner*, *Mr. Stone* replied that the angular distance between the centre and the first dark ring, where there was total darkness, was divided into twenty equal parts, and the illumination computed for each part.

Mr. Plummer said that the distance of which Mr. Stone spoke was very small. He had himself calculated and measured it, and at first had believed that the large area covered by the photographic image might be accounted for by diffraction. It was not so, however. The brilliancy of the telescopic stellar disk at the third diffraction ring was only about one thousandth of the light at the centre, and in a 13-inch equatoreal with a 3-inch stop this extends to a distance from the centre of only 1″·3, whilst in the photographic image the area extends it might be 30″ from the precise centre. Could that have anything to do with the diffraction rings?

Mr. Stone replied that he was not speaking of the photographic image or of the diffraction rings. The disk he had taken was defined by the first dark ring from the centre. He had divided it into twenty equal parts and computed the illumination of each independently; and the total light falling on the entire disk so defined was eighty-five times that falling on its central portion. Any method which gradually extinguished the light of the star would cause the loss of the light of the outer portions of the disk first.

Mr. Plummer. The extinction method is purely differential.

The Astronomer Royal called attention to the fact that the eye did not perceive geometrical points of light, but a surface, and diffraction disks had to be dealt with in the eye as well as in the telescope. He admitted the gradation in light of which Mr. Stone had spoken, but unless a very high magnifying-power were used the eye would practically see the whole light spread nearly evenly over the whole disk. The eye was in fact a telescope of small aperture and without any magnifying-power, whilst in astronomy telescopes of large aperture were used, and with varying magnifying-powers, and the question was, what magnifying-power was used? These calculations of the intensity of the light at certain points of the diffraction disks of the telescope had no force, for they must consider that every point of the disk formed by the telescope was spread out by the eye into another disk, which might bear a very large proportion to the disk in the telescope. He thought, speaking just as the matter struck him now, and not having worked it out, that it probably depended very much on whether a magnifying-power of 100 or one of say 1000 were used, whether the degradation of light from the centre to the edge of the disk would have any appreciable effect in observations or not. There was, it was true, a gradation of light; but in the method of extinction by the wedge-photometer, if the light came solely from the point in the centre of the diffraction disk, the eye would still spread it out into a disk.

Mr. Stone. Any one who has watched a large star through a telescope knows that when clouds are passing the star becomes distinctly smaller.

The Astronomer Royal. Probably because high powers were used. But I do not see that the point would affect the comparison of one star with another, photometrically or photographically. Supposing two stars were equal in magnitude as judged by the eye, the brightness of the centres of the disks of each would be equal, and so would be the illumination of the entire disks, but not necessarily the photographic disks, as we might have in one star or the other more of the violet rays than of the visual.

Mr. Ranyard pointed out that the photographic disks were on a very much larger scale, perhaps 30″ in diameter.

The Astronomer Royal replied that that had nothing to do with the present question.

Mr. Ranyard had tried experiments to see if the photographic disks were due to the light spreading within the film, and had proved that they were not. He had interposed a piece of platinum foil before the sensitive film when photographing a brilliant star, and had found the photographic irradiation sharply cut off by the opaque foil, whilst it extended in all other directions. These disks were therefore due to light falling on the plate from the front, and not to an action spreading within the film.

The Astronomer Royal replied that Capt. Abney had shown that the photographic disks were formed by absorption in the photographic film of an action spreading in every direction.

Mr. Knobel found something very anomalous in magnitude determinations, whether made by absorption photometers or by eye estimation; and he called attention to a paper published recently in the 'Monthly Notices,' wherein Mr. Gore gave his determinations of the magnitude of the new star in Orion from December to March. Using a binocular and observing with the eye only, but being skilled and experienced in the work, he found the degradation of the light of the star to be three magnitudes. Prof. Pritchard, on the other hand, by his photometric observations, made the degradation only half a magnitude. There was something very anomalous, and which required explanation, in such a result.

Mr. Stone thought, as to the size of the star-disks, that it was evident to any one who had observed a large bright star like Sirius, whilst cloud was passing, that the disk became visibly and distinctly smaller. There was no doubt whatever about it.

The Astronomer Royal replied that the true diffraction disk was not seen in a bright star like Sirius; it was mixed up with the first, second, and third rings.

Mr. Stone had seen the first disk of Sirius perfectly distinctly. But if a smaller star was taken, say ϵ Boötis, when cloud passed over it, it would change in just the same way, the magnitude of the apparent disk diminishing under the eye, and as the cloud grew very dense the star would appear to be merely a point, the closest approximation to a mathematical point which the eye was capable of seeing.

The Astronomer Royal was still of opinion that with a clear sky and a large telescope, say 6 or more inches aperture, the true diffraction disk of Sirius would be so mixed up with the first, second, and third rings, that the phenomenon just described would be accounted for by the fact, that as the light diminished to that of a star of the third or fourth magnitude the true diffraction disk would at length be seen.

Capt. Noble had been observing η Ursæ Majoris with the Matthew Transit instrument a few days back, and there had been a kind of blue haze over the sky. The star was seen as clearly as he had ever seen it, but it was cut down to the merest pin point.

Mr. Common asked Mr. Ranyard if he was correct in supposing that he had covered part of his plate with platinum foil, and that he had found the photographic action stopped by the foil; so that all the action seen in a photograph of a first magnitude star was due to something intercepted by the platinum foil.

Mr. Ranyard replied that that was what he meant. It was very difficult to bring the foil into the centre of the star's image; but it cut the edge of the photographic image sharply off. Besides, the larger the aperture the larger would be the photographic image; but it was well known that, with increased aperture, the diffraction rings diminished in size. The two could therefore have no connection with each other.

The President. The Society has present this evening a Fellow who used to be familiar amongst us, but who has not visited us for three years. Mr. Marth has some remarks he would like to make. (Applause.)

Mr. Marth wished to say a few words with respect to his diagrams of the "Intersects" of the orbits of the solar system, and he showed on one of them the relations of the orbits of the great comets of 1843, 1880, and 1882. The comet seen in the eclipse of 1882 was represented on the diagram by a red line. If the comet was to be recognized at some future return, the "intersect" of the comet must, if it be identical, show the same longitude as that belonging to the corresponding point in that line. It was possible that it might be a member of the same group as the comets of 1843 and 1880. It was not yet decided whether those two comets might not be the same body. It depended much upon the effect of the resistance experienced in the immediate neighbourhood of the Sun. That resistance had not been effective in the case of the comet of 1882, but it had not approached the Sun so closely as the other two. He wished to draw special attention to the case of Olbers' comet, the return of which was expected next December. The exact time of the return was uncertain; but by cutting out a piece of cardboard to represent the Earth's orbit and applying it to the diagram, the conditions for its visibility, according to the actual date of its return, were seen at once. This was a special case in illustration of the usefulness of the "intersects," but he had a further view with regard to them. The orbits of the solar system were rapidly increasing in number, and this device enabled a fair idea to be obtained of their relationships to each other—a most important point. For instance, it was asked, "How came Biela's comet to divide? Did it overtake a minor planet?" Such a question could be answered by this diagram. What had happened to De Vico's comet of 1844? It might turn up again after having suffered such perturbations that we could no longer recognize the orbit. The intersects would at least show the point where the motion had undergone the change. Von Asten thought that something had interfered with Encke's comet; the idea was a mistaken one, but the question would arise with regard to other comets, and then the intersects would show which was the disturbing body. But he had meant merely to speak of Olbers' comet. Olbers had discovered it at the beginning of March, 1815. He had been made a member of the Corps Legislatif, and had been to Paris, and been very kindly received by Laplace, with whom he had many great discussions on different subjects; amongst others, on what is called the "capture" theory of comets, which had been started by Sir W. Herschel and accepted by Laplace. Olbers objected to the theory, that though there might be captured comets he knew of none. The comet of 1815 and Halley's comet were dead against the theory. The recent talk about the capture of comets is therefore only the old discussion of 1815 revived.

The President was sure every one would admire Mr. Marth's energy and industry in calculating these intersects and drawing these beautiful diagrams. He saw the importance of the problems Mr. Marth had alluded to, and how curious the intersects were as a representation of the solar system, but did not see how the proximities were to be inferred from them.

Mr. Marth said he had explained that point in his printed papers.

The President called on Mr. Neison to read a paper "On Delaunay's Method of calculating the Terms of Long Period in the Motion of the Moon."

Mr. Neison, of whose return to England most of the Fellows had been ignorant, was very cordially welcomed.

Mr. Neison expressed his pleasure at meeting his old friends again. He would not read his paper, which was a long one. The former papers he had written on the lunar theory had been criticised by various astronomers during his absence in Natal, and he had not been able to reply to them at the time, as he had not either his own papers or the publications of other astronomers at hand in the colony. He had endeavoured to reply to those criticisms now. The old direct method of calculating inequalities gave the results which had originally been deduced by Hansen and subsequently by himself. But the elegant method introduced by Delaunay gave different results; and you could not by it reconcile observation and theory: whereas the simple theory introduced by Laplace gave the possibility of so doing. He believed Delaunay's method was imperfect, but he found astronomers had not accepted his view, and called upon him for proof. The purpose of the present paper was to show, first, that Delaunay's method gave a result identical with that which would be obtained by the direct method if nine tenths of the difficult part of the work was left out. But why should it be left out? He next showed that the omitted terms did not disappear. Then he took Delaunay's method and showed it proceeded on the assumption that if by any transposition the first powers were made to disappear, the other powers and products disappeared likewise. Next he showed that this assumption was incorrect; and, lastly, that if those powers and products are taken into consideration, the same result was reached as by the direct method. He should look with interest to see what the astronomers who used Delaunay's method had to reply to these considerations.

Mr. Buckney gave the following account of a paper he had written

"On the Superiority of Zinc and Steel Pendulums," in consequence of a statement made by Dr. Waldo at the last meeting. He said: Dr. Waldo gave us an account of some improvements in astronomical clocks which had been made in Yale Observatory, the net result of which was that clock-errors had been reduced about 25 per cent. on the best known existing clocks. Of course that is a very important gain if it can be substantiated. When making such a statement it would have been better had Dr. Waldo given us some figures by which we could verify the conclusions at which he had arrived. In the absence of such we can only estimate the value of the improvements by seeing and discussing what they are. In the first place he proposes that his clock should have a heavy mercurial pendulum weighing from forty-five to sixty pounds, the jars containing mercury, as well as the pendulum-rods, to be of steel. In ordinary cases the jars are of iron, but the rods are always of steel I believe; so that it does not matter very much about the jar, that remains the same as before. The suspension of the pendulum was on knife-edges in lieu of suspension by a spring. The escapement he used was a modification of one of the forms of Denison's gravity escapement. I do not know whether it was any improvement; I am unable to say. Dr. Waldo gave so very little information about it; but what he did give evidently showed that the improvement would have very little effect on the time of vibration of the pendulum. The only advantage would be that the act of unlocking, which was done by the pendulum, might be rather more easy. He insisted on a very massive support for the pendulum, and there, I think, every one will agree with him. The pendulum no doubt ought to have a perfectly rigid suspension. The only thing I wish to deal with at the present moment is the pendulum itself, because I have found considerable errors arise from using a very large bob with a mercurial pendulum. About eighteen years ago the matter came very prominently to my notice, when making designs for the present sidereal standard clock of the Royal Observatory. The clock was to be constructed according to Sir George Airy's specification, and one of the points was that it was to have a mercurial pendulum. At the time this clock was set going I had some other clocks which were to be used in transit of Venus expeditions, and for the sake of portability they had pendulums made of zinc and steel constructed in what was at that time the ordinary way; part of the compensation of the pendulum being performed by the expansion of the bob. I found all these clocks were very sluggish in their action. They were put in a room in which were means of raising the temperature. When the temperature was raised it took, before the clocks settled down to the new temperature, twenty-four hours for the zinc and steel; but with the larger mercurial pendulum nearly two days. I came to the conclusion that it was owing to the bob taking a longer time to accommodate itself to the increased temperature. I then supported the bobs of the zinc and steel pendulums at their centre of gravity instead of at one end, so that the expansion would have no influence whatever on the motion of the pendulum. This made a very great improvement indeed, and in the end I laid the matter before Sir George Airy and obtained his consent to put a zinc and steel pendulum to the Greenwich clock, which it now has. That was put before it went to Greenwich. I made afterwards some experiments with two mercurial pendulums and a pendulum of zinc and steel. I took in one instance a two-inch mercurial jar, and in the place of the steel rod I mounted a glass tube and filled the whole with mercury until it stood some distance in the glass tube. Then I put it into hot water of a temperature of perhaps 150°. The first effect of that was to cause the mercury to sink rapidly in the tube, showing that the jar itself had expanded before the mercury took up any increase of temperature whatever. If that took place in the clock, which it would with any change of temperature, although in a much smaller degree, you would have the error due to the change of temperature aggravated instead of corrected, owing to the steel rod expanding before the mercury; you would have the steel rod *expanding* and the mercury *sinking* in the jar—to a small extent if you will, but still that is the first result of a rise of temperature. I made another experiment which bears on the sluggish action of the pendulum, and shows most conclusively the disadvantage of having a large mercurial jar. I had two jars, one two inches and one two and three quarter inches in diameter; I filled these with mercury to a proper height, and I put a thermometer into each of them. The thermometer was plunged down into the centre of the mercury. I took at the same time the outer steel tube, or, rather, a short length of it, and one of the zinc and steel pendulums. I put the zinc tube inside that, and again inside that I put a thermometer; I put all these three, the two jars and the piece of zinc tube, in a vessel, which I filled with water, and put on a gas-stove. I kept the water at about 200° for a couple of hours, until it was evident that the high temperature had thoroughly pervaded the masses in the middle of the bobs. The thermometers all reading the same, I took them out of the water and I noticed the time that each one took to cool down a certain definite number of degrees. The observations began when each one reached 180°; I noted the time each one took from 180° to 140°. The zinc and steel pendulum cooled down that amount in four minutes; the 2-inch mercurial jar in twenty-one minutes; the 2¾-inch mercurial jar in twenty-nine and a half minutes. The times severally occupied in cooling down the next twenty degrees were five minutes, fifteen minutes, and twenty-two minutes. In cooling down from 120° to 100° the time occupied was eight minutes, twenty-four minutes, and thirty-eight minutes. From 100° to 90° the time was five minutes, nineteen minutes, and twenty-nine minutes; from 80° to 70°, below which point the observations were not carried, the time occupied was twenty-six and a half minutes, seventy minutes, and one hundred and fifteen minutes. The variations were proportional, and gave a ratio of 1, 3, and 5, showing that a zinc and steel pendulum would accommodate itself to a new temperature in one third of the time that a 2-inch mercurial jar would, and in one fifth of the time of a 2¾ inch jar; and of course the clock-errors might fairly be assumed to be in those proportions. But the zinc and steel pendulum has an advantage that is not shown in this experiment. Ordinarily the outer steel tube is cut away very much, so as to expose as much surface of the zinc tube as possible, and the zinc tube itself is pierced with many holes, so as to allow the temperature to reach the internal rod. That would give the zinc pendulum this advantage, that it would tend to make its action simultaneous, a real advantage which did not enter into my experiments, because I wanted to keep the water out of the inside, and of course I could not put holes in it. Dr. Waldo claims as one of the points in his clock that he has from 45 pounds to 60 pounds of mercury. That would mean that one jar was 4 inches in diameter and one 5 inches; and these errors seem to be pretty much according to the size of the jars, and therefore his 5-inch pendulum would take about twenty times as long to accommodate itself to a change of temperature as a zinc and steel pendulum. He claims an advantage on account of the extra weight of the pendulum; but you can give that to a zinc and steel pendulum by increasing the size of the bob, which does not enter at all into the compensation, all the other parts remaining the same as long as you do not overload the zinc which has to carry the weight. I have given in the paper a record of the performance of one of these clocks which was intended to be used in the transit of Venus expedition. I take it because it was exposed to very great changes of temperature. It was placed in one of the observing huts and was kept going for a period of over six months in the grounds of the Royal Observatory. The temperatures of the hut varied very much as the temperature of the external air, and the going of that clock I am sure is much better than you would get from any mercurial pendulum, certainly with a jar of large size. Of course in order that you may get a clock to go properly you must have all the different parts which perform the duty of compensation acting simultaneously. In the zinc and steel pendulums I believe the action to be very nearly simultaneous, inasmuch as the parts are almost of the same bulk. There is not one thick piece acting in one direction and a thin piece in another; whereas in the mercurial pendulum you have got the expansion of the steel rod, which is very small, and you compensate that by the expansion of the mercury in the bob, which is very large; and the one evidently does not act so quickly as the other. The same thing has been observed in thermometers. The bulbs of thermometers I believe used to be made very much larger than they are now. In a clock-pendulum weight is an advantage; but if, in order to obtain that weight, you get sluggish action, you will, in my opinion, commit an error which is very much greater than the one you are trying to obviate.

In answer to the *Astronomer Royal*, *Mr. Buckney* said that the pendulum of the Westminster clock was 6 cwt., and was on that account made of zinc and steel.

Thanks were voted to *Mr. Buckney* for his paper.

Mr. Howlett was called upon to read a paper "On the asserted Foreshortening of the inner side of the Penumbræ of Sun-spots when near the Sun's Limb." He said that every one knew of the theory started by Dr. Wilson towards the end of last century. He had stated that when a spot was near the limb the nucleus would lie close to the inner side of the spot and the outer side of the penumbra greatly predominate, whereas when near the centre of the disk the spot would be circular, with the umbra in the centre. The inference was that spots were depressions. But he (Mr. Howlett) found those effects sometimes wholly wanting, and he instanced a very symmetrical spot which appeared on April 12 last, and which showed the umbra as central when the spot was close to the limb. Father Perry had confirmed the observation. Dr. Wilson and Sir W. Herschel, who supported his theory, had given no measurements; but the statements of the former were very careful and deliberate as to what he had observed. Mr. Howlett would not suggest that Dr. Wilson was in error; he thought the fact was rather that solar spots were of different descriptions. Prof. Challis had suggested that the refractive effects of the Sun's atmosphere might flatten, modify, and even bring features into view which were actually beyond the limb. This might perhaps account for some of the appearances sometimes observed; he could not speak on that point, but he was sure that the majority of spots did not present the appearance which Prof. Wilson had attributed to them, and that if they were depressions at all, their depth must be exceedingly slight.

Mr. Maunder said Dr. De La Rue, in his 'Researches on Solar Physics,' measured a number of photographs taken with the Kew photo-heliograph with reference to this very question, and found that about one out of every seven was an exception to Dr. Wilson's rule, the great majority therefore following it. His own impression, though he could give no numerical details, derived from the scrutiny of thousands of solar photographs, was in accord with Dr. De La Rue's result; a certain proportion showed a distinct contradiction to Wilson's rule, but the great majority supported it. But even if not cup-shaped in their interior, there was little doubt that spots were so in their exterior portions, as they were generally surrounded by bright faculæ showing a decidedly higher state of the general surface.

The following papers were also presented:—

Prof. A. Hall. "Observations of the Satellites of Saturn and Mars and of the companion of Sirius made at the U.S. Naval Observatory, Washington."

J. E. Gore. "On the Orbit of ζ Sagittarii."

L. A. Eddie. "Observations of Comet Fabry (1885 *d*) made at Grahamstown, Cape of Good Hope."

R. Bryant. "On Kepler's Problem."

Royal Observatory, Greenwich. "Observations of Comet Brooks (1886 *a*)."

A. Marth. "Ephemerides of the Satellites of Saturn, 1886–87."

N. E. Green. "The Northern Hemisphere of Mars."

A. C. Ranyard. "Note with regard to the Invention of the Achromatic Telescope."

Commander J. L. Heane, F.R.G.S., was duly elected a Fellow of the Society.

The Meeting adjourned at 10 P.M.

Meteor Notes.

DURING a series of morning watches at the end of April and beginning of May, I found several new showers. I may mention three of these, viz.:—at 327° +35°, April 30–May 9; 345° +37°, May 3–4; and 347° +55°, April 30–May 1. The former may possibly have some relation to Fabry's Comet, the radiant-point of the latter at the descending node, April 26, being 322°·6 +36°·9 as computed by Mr. O. C. Wendell ('Sidereal Messenger,' May 1886, p. 152). But the observed meteor-shower being a feeble one (though the point of radiation is very exact and certain), and the Earth's distance from the cometary orbit being more than 10 million miles, it is extremely doubtful whether the resemblance proves the identity of the comet and meteors.

During the week from May 28 to June 4 last, I recorded about 50 shooting-stars, and found a well-defined radiant of bright streak-leaving meteors at 333° +27°. This position agrees with a shower I formerly derived from the projection of 105 paths in the Italian observations for May 30, 1870. I believe this stream is the most conspicuous one visible at the end of May and early in June. The same region just N.E of ι Pegasi becomes the centre of one of the best observed of all the minor showers in July, particularly during the last week of that month. I find a mean of 11 closely accordant observations of the July Pegasids is at 334°·5 +27°·3. In Mr. Greg's Catalogue of 1876, the average position is placed at 338° +26°, July 1–Aug. 15, which is slightly E. of the real centre.

On May 30 this year, I also noticed a display of slow, short meteors from 290° +60°, E. of ο Draconis, and from 304° +22° in Vulpecula.

On June 4 several bright, swift meteors were recorded from the point 313° +60° near η Cephei. I obtained a good view of this shower on June 13, 1885, and it forms one of the richest streams of the epoch. These midsummer Cepheids were pointed out by Mr. Greg some years ago, and he gave their radiant very accurately at 315° +60°, for the period June 11 to July 11. It is clear, however, that it becomes active at least a week earlier than this. The shower is perhaps of more than ordinary interest from the fact that Petersen's Comet of 1850 has a radiant at 313° +60°·5, for June 23, at its descending node, not far outside the Earth's track. But the significance of the accordance loses much of its weight by the long duration of the star-shower, and the absence of a prominent display on the special night * when the Earth makes her nearest approach to the node. There are successive showers from Cepheus all through the summer months, and in October the fall of meteors is still very pronounced from the same region near η Cephei. The Catalogue of Heis includes a radiant at 315° +59° (50 meteors), for Oct. 3–Nov. 13, and in October 1879 I recognized it from 16 paths intersecting at 316° +59°.

Bristol, 1886, June 11. W. F. DENNING.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Nomenclature of the Constellations near the South Pole.

GENTLEMEN,—

With your permission I would call attention to some inaccuracies of statement which are to be found in several books on astronomy with reference to the first naming of the constellations near the south pole. Thus in the article on "Astronomy," in the ninth edition of the 'Encyclopædia Britannica,' eight of these are stated (p. 817) to have been added by Halley, who in point of fact never attempted to form or name any constellation, with the single exception of the small group which he detached from Argo and called Robur Carolinum, or King Charles's Oak. The statement of Arago ('Astronomie Populaire,' livr. viii. chap. 5), that Bayer "d'après Americ Vespuce et les navigateurs qui jouirent les premiers du ciel du Nouveau Monde, ajouta douze constellations nouvelles aux constellations australes de Ptolemée," has been frequently misunderstood to mean that Bayer first introduced on maps the twelve southern constellations in question †.

A reference to Bayer will show that he truly stated the matter in this way; that various navigators had given names to some of the constellations in the extreme southern part of the heavens, but that the first to clearly define and locate these was Petrus Theodori, whom he calls "Nauclerus peritissimus." The real name of this skilful pilot, who accompanied the Dutch expedition of four ships which sailed to the East Indies in 1595, was Pieter Dircksz Keyser. As might be expected, due reference to his name, as practically the author of the nomenclature in question, is given in that well-known and highly valued repertory, M. Houzeau's 'Vade Mecum de l'Astronomie." But in this reference there is an error respecting Keyser himself, which it may be well to point out for correction in future editions. It is said of him that he, in 1597, "revint d'un voyage aux Indes." As a matter of fact he never returned *, as he died off Bantam in Java, on the 11th (not the 1st, as stated by Wolf in his 'Geschichte der Astronomie') of September 1596. One of the ships of the fleet had to be abandoned and was burnt on the 1st of January 1597; the remainder completed their return journey in the following August. Soon after Plancius, whose pupil Keyser had formerly been, obtained possession of his observations of the southern stars, by which means the constellations formed by him were afterwards inserted on celestial globes and charts. Bayer gave at the end of his *Uranometria* (published, it will be remembered, in 1603) a map containing these twelve constellations, but without attempting to affix letters to the stars in them, as he had done in his maps of the ancient groups. Halley adopted these names of constellations in his southern catalogue; including also those named by Royer, and, as I remarked above, his own asterism detached from Argo and called by him Robur Carolinum. The stars in these constellations he indicates entirely by their positions in the figures; and, as all astronomers are aware, Flamsteed took care to give similar positions, in addition to affixing Bayer's letters, to most of the stars in the British Catalogue. It was reserved for Lacaille to give letters to the stars in the constellations near the south pole. He endeavoured, unlike Bayer, to make the order of letters follow strictly that of the brightnesses of the stars. To use his own words:—"Lucidiores primis alphabeti litteris notavi, ita ut diversi gradus magnitudinis aut claritatis ordinem, ut plurimùm sequantur alphabeticum" ('Cœlum Australe Stelliferum,' p. 157 †). Yet, as Dr. Gould remarks in his 'Uranometria Argentina,' this object was by no means accurately carried out, there being many exceptions to this intended correspondence, the cause of which, as Dr. Gould points out (p. 54), is not far to seek. Very few of the 9766 stars contained in the 'Cœlum Australe' were observed more than once, so that the estimates of their magnitude were necessarily hasty and often

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* 1886, June 23. No meteors were observed from Cepheus during a watch of 1½ hours on this night.

† They are Pavo, Toucana, Grus, Phœnix, Dorado, Piscis Volans, Hydrus, Chamæleon, Apis or Musca, Avis Indica or Apus, Triangulum Australe, and Indus.

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[*] See a paper by Olbers, "Ueber die neuern Sternbilder," in Schumacher's 'Jahrbuch für 1840,' p. 249; also, for an account of the voyage, R. A. C. de Renneville's "Recueil des Voyages qui ont servi à l'établissement et aux progrès de la Compagnie des Indes Orientales formée dans les Provinces Unies des Païs Bas."

[†] *i.e.* in numeration; no number of page is actually printed after 141, the first of those which contain the Southern Catalogue.

affected by atmospheric influences. Moreover the notation seems to have been adjusted after Lacaille's return to France, when there was no means of referring to the sky in doubtful cases; and he also appears to have modified his observed magnitudes in some instances so as to produce a better accordance with those assigned by Halley when observing at St. Helena.

Blackheath, 1886, May 3.

Yours faithfully,
W. T. LYNN.

The Density of Algol.

GENTLEMEN,—

With reference to Mr. Maxwell Hall's very interesting paper on this subject in the June number of the 'Observatory,' I wish to point out that the data he uses are not quite correct. At maximum Algol is not quite equal to a star of the second magnitude. Sir John Herschel estimated it 2·62; it is 2·31 in the 'Harvard Photometry' and 2·40 in the 'Uranometria Nova Oxoniensis;' and at minimum it is certainly brighter than the fourth magnitude. According to Prof. Schönfeld's observations, the variation of light is included between the magnitudes 2·2 and 3·7. Taking the "light ratio" as 2·512 (the value now generally adopted), we have

$$L_{2\cdot2} = (2\cdot512)^{1\cdot5} L_{3\cdot7},$$

or Light at maximum = 3·981 × Light at minimum;

$$\therefore \left(\frac{r'}{r}\right)^2 = \frac{3\cdot981 - 1}{3\cdot981} = 0\cdot749$$

and
$$\frac{r'}{r} = 0\cdot865.$$

Schönfeld gives the light at maximum as 20·8, and the light at minimum as 5·6, whence

$$\left(\frac{r'}{r}\right)^2 = \frac{20\cdot8 - 5\cdot6}{20\cdot8} = 0\cdot7307$$

and
$$\frac{r'}{r} = 0\cdot854.$$

According to the late Prof. Schmidt's observations, the fluctuations of light extend over 9¼ hours; and from photometric measures at Harvard, Prof. Pickering finds the duration of the light variation to amount to 10 hours. Adopting the latter result, we have

$$\frac{2(r - r')}{2\pi a} = \frac{15}{4129}$$

and
$$\frac{2r'}{2\pi a} = \frac{300}{4129},$$

have a period of little more than 5 years. The 'Annuaire' indeed gives the period of Tempel's Comet as 6·507 years, in which case it could not have passed its perihelion in the year 1766; but this period seems to be wrong, inasmuch as its three observed visits in 1867, 1873, and 1879 took place at intervals of rather less than 6 years. A period of about 19 days less than 6 years would bring this comet to its perihelion at the same time with Burckhardt's; but while there is a good agreement between the other elements, the difference in the computed perihelion distance is large. I give the elements of Tempel's Comet as computed by Hind on its visit of 1873:—

	π.	☊.	i.	q.	μ.
Comet of 1766	251° 13′	74° 11′	8° 1′	0·3989	Direct.
Tempel's Comet 1867 ...	238 1	78 43	9 46	1·2872	Direct.

The 'Annuaire' brings π and ☊ into closer agreement, but aggravates the contrast of perihelion distances. This comet of 1766 has been conjectured to be identical with that of Winnecke, but the latter could scarcely have passed its perihelion in the year 1766.

The Comet of Faye is possibly identical with that of 1366, but Chambers omits to state whether the motion of the latter comet was direct or retrograde. If direct, the agreement of elements is very fair, and assuming the number of revolutions to be 63 we obtain a period of 7·571 years. The actual period according to the 'Annuaire' is 7·566 years.

I will only add one other conjecture. The elements in this case show a considerable discrepancy, but possibly the difference would diminish on computing elliptic orbits for the first two comets. It is that Westphal's Comet of 1852 is identical with the comets of 1779 and 1706, its true period being between 72 and 73 years, instead of between 67 and 68, as computed in 1852.

I subjoin the elements in the last two instances:—

	π.	☊.	i.	q.	μ.
Comet of 1366	66°	212°	6°	0·958	?
Faye's Comet 1843 ...	49 34′	209 29′	11 22′	1·6925	Direct.

Comet of 1706	72° 29′	13° 11′	55° 14′	0·4258	Direct.
Comet of 1779	87 14	25 4	32 30	0·7131	Direct.
Westphal 1852.........	43 12	346 13	40 58	1·2510	Direct.

Dublin, 1886, June 14. W. H. S. Monck.

NOTES.

Royal Observatory, Greenwich.—The annual visitation of this Observatory was on Saturday, June 5, when the Astronomer Royal presented his Report for the past year to the Board of Visitors. From Section II., Astronomical Observations, it appears that considerable care has been bestowed on the investigation of the "Personal Equation." "A discussion of the collimation-observations made throughout the year 1885 with the reversion prism shows that for the regular observers the personality depending on the apparent direction of measurement is extremely small. The personality due to direction of motion, as deduced from the results of reversed and ordinary transits of clock-stars with the reversion prism, appears to be more decided, though the amount is small except in the case of one observer." The Personal Equation Instrument, mentioned in the last report, was completed in the autumn, and the absolute personal equations obtained by its means seem to show that all the observers observe too late, the difference between the several observers agreeing well with the relative personal equations found from observation of clock stars. The personal equations in eye-and-ear transits, deduced from observations of stars both chronographically and by the eye-and-ear method at the same transit, are nearly the same as for chronographic transits, except in the case of one observer, for whom the difference amounts to about $0^{s}.6$. Mr. Turner has recently investigated the discordance between observations for coincidences of the collimators made respectively through the apertures in the cube of the transit-circle and with the instrument raised, and has shown it to be due to the cutting off of portions of the object-glasses by the cube, and not to any effect of temperature. The usual observations of the Sun, Moon, Planets, and fundamental stars have been regularly made during the past year, together with other stars from a working catalogue of some 2750 stars. A ten-year catalogue, epoch 1880·0, will be in formation at the end of 1886. The annual catalogue of stars observed in 1885 contains about 1250 stars. Observations of the Moon with the altazimuth have as usual been restricted to the period from last quarter to first quarter of each lunation. "The optical performance of the Lassell equatoreal appears now to be satisfactory." In the spectroscopic department the measures of the displacement of lines in stellar spectra, for the determination of the motions of stars in the line of sight, have been carried on as usual. The observations of Sirius during the past twelve months indicate, as in the last three years, a displacement of the F line towards the blue (corresponding to a motion of approach), the amount being slightly larger than in the preceding year." The spectrum of Nova Andromedæ was examined on six nights, and that of Nova Orionis on three nights. Comet *e* 1885 was observed with the spectroscope on two nights, and the red star 51 Schjellerup on one night. The areas of both spots and faculæ, as shown from photographs of the Sun, have a marked diminution in 1885 as compared with 1884, the mean daily area for 1885 being in each case only three fourths that of the previous year. The diminution in the spotted area has taken place principally in the northern hemisphere. There were 12 days since the date of the last report on which the Sun's disk was observed to be free from spots.

The mean temperature of the year 1885 was 48°·6, being 0°·7 lower than the average of the preceding 44 years. The maximum air temperature (in the shade) was 90°·2 on July 26, and the minimum 22°·3 on Jan. 22. As regards the long-continued cold weather this spring: the mean temperature for the whole period 1886, Jan. 5 to March 18, was 33°·8, being 5°·9 below the average; the lowest temperature recorded was 16°·5 on 1886, Jan. 7. The greatest daily motion of the air was 704 miles on Jan. 11. The number of hours of bright sunshine recorded by Campbell's sunshine instrument during 1885 was 1261, which is about 60 hours more than the average of the preceding 8 years. The period of the annual trial of chronometers is to be changed so that the rating will commence in July instead of January. There is also to be a trial of Deck Watches in November. No further action has been taken as regards the establishment of hourly time-signals at the Lizard or Start, as the arrangements for preliminary trial of a collapsible cone at Devonport are not yet completed.

No change has taken place in the constitution of the staff. Under the heading of General Remarks, the Astronomer Royal says:—

"Commencing with the year 1885, Greenwich civil time, reckoning from midnight to midnight and counting from 0 to 24 hours, has been adopted in the Spectroscopic and Photographic Results as well as in the Magnetical and Meteorological. It is proposed to defer the introduction of this time-reckoning into the Astronomical Results till the year 1891, for which year the Board of Visitors have recommended its adoption in the Nautical Almanac. In an Observatory such as this, where observations of various classes are carried on, there is, however, considerable inconvenience in the retention of the present astronomical day, which now involves the use of two systems of reckoning mean solar time in the same establishment.

"The construction of an object-glass of 28 inches aperture and of 28 feet focal length, with suitable tube, to be mounted on the South-east Equatoreal, has been authorised by the Government, and the necessary funds have been provided in the estimates. The work has been entrusted to Mr. Grubb, with whom I have arranged the details of the tube, which is to be of special construction, adapted to the conditions of the mounting, and available for spectroscopy and photography as well as for eye-observations. Mr. Grubb proposes to provide means for readily separating the lenses of the object-glass to such a distance as will give the proper correction for photographic rays. Messrs. Chance are engaged in the manufacture of the glass for the lenses, and have already made a flint disk, which promises to be very satisfactory.

"In view of the recent development of astronomical photography, I propose to have constructed, for use with the present 12¾ inch refractor of the South-east Equatoreal, a combination of a convex flint and concave crown lens, which, when placed about 2 feet within the focus, would correct the [illegible]ic aberration of the object-glass for the photographic rays without alteration of the focal length. If this plan succeeds, the instrument would then be well adapted for photography, thanks to the firmness of its mounting and the excellence of its driving clock."

THE UNIVERSITY OBSERVATORY, OXFORD.—The Eleventh Annual Report of the Savilian Professor of Astronomy was read to the Board of Visitors of the University Observatory, on June 16, 1886. We learn from it that the practical lectures offered at the Observatory have been attended by the average number of students, and that the instruments generally are in excellent working order. The small observatory erected on the roof of the Lecture room has been found useful in the course of the year for the practical instruction of the students. The De la Rue reflector, after some thirty years of constant work, has exhibited the natural symptoms of wear in the more delicate working parts, and Dr. De la Rue, with his accustomed generosity, placed a sum of money in Prof. Pritchard's hands for the renewal of the parts in question. A new and very effective slow motion in declination has already been added, but further modifications in the Right Ascension movement will be necessary.

The Astronomical work of the year has included the publication of the 'Uranometria Nova Oxoniensis,' which has been followed by the award of the Gold Medal conferred by the Royal Astronomical Society for the researches contained in that work and in previous communications made to that learned society. In order to complete this work, the measurement of the magnitude of an equatoreal zone of stars has been undertaken, by means of which it will now be possible to connect the comparative brightness of stars in the southern hemisphere with those already determined in the northern. The two Novæ in the constellations of Andromeda and Orion have also been carefully observed.

Prof. Pritchard proposes now to direct his attention to astronomical photography, a department of work for which the observatory is well equipped and in which it has already secured some considerable results.

The directions in which these investigations have been thus applied refer, 1st, to the relation which exists between the photometric and the photographic magnitude of stars; 2nd, to the reliable uniformity of the photographic film; and 3rd, to the amount of astronomical accuracy attainable by measurements on the same. Prof. Pritchard hopes that in the course of a year the parallax of certain stars will be redetermined by this new process, even to a greater degree of accuracy than has hitherto been achieved by direct instrumental application.

The Report concludes with the statement that the finances of the Observatory are in a satisfactory condition, and with a recognition of the services of Messrs. Plummer and Jenkins, the two assistants.

[illegible] MERIDIAN INSTRUMENTS.*—In this paper [illegible] an exhaustive discussion of the subject [illegible] available for eliminating its effects from [illegible] separately the flexure of transit instruments [illegible] circles. The former divide themselves into [illegible] their telescopes are straight or bent; but [illegible] the effects of flexure are by far the [illegible] in some instances being as great [illegible] for the flexure in right ascension [illegible] — a sin [illegible] the upper [illegible] according as the clamp is west or east. [illegible] by means of a horizontal and a [illegible] value of c from the latter in combination [illegible] : but the only method of [illegible] by observing transits of stars properly [illegible] equations from which c is [illegible] squares. It is also shown that the [illegible] satisfactorily eliminated from the right [illegible] taking the mean of the four results [illegible] directly and by reflection with the [illegible] west and east.

[illegible] vertical circles, Prof. Harkness limits [illegible] the form A sin z + B cos z, partly because [illegible] of the series are probably very small [illegible] and partly to avoid the difficulties [illegible] are included in the observation [illegible] the highest value in [illegible] flexure of a vertical circle can be [illegible] a pair of collimators [illegible] star-observations, made [illegible] the same purpose. A [illegible] the flexure of a vertical [illegible] and eye-end, with Bessel's [illegible] by observing a star both [illegible] with clamp successively west and east, [illegible] four observations, demonstrates the superiority of the latter method, and it is, in Prof. Harkness' opinion, the most satisfactory procedure hitherto devised for freeing an observed declination from the effect of flexure. One of the most important facts brought out in this paper is that whenever the flexure corrections are either neglected or imperfectly known, the effect of using a nadir-point determined from reflection observations of stars is to make the nadir-point a function of the zenith-distances of the stars employed, and thus to substitute an unstable point for the fixed one given by the collimating eyepiece. In fundamental work such a substitution is, of course, absolutely fatal. Prof. Harkness shows that when there are terms in the flexure depending on multiples of the zenith distance they cannot in general be completely eliminated, and therefore that star-places derived from a single instrument are likely to be affected by systematic errors, which will appear when the work of different instruments is compared together. The detection and elimination of the errors in question can probably, the author thinks, be greatly facilitated by the use of equal altitude instruments of the zenith telescope class, which have been found to be so remarkably free from all systematic errors.

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* Washington Observations for 1882, Appendix III.

In the concluding paragraph of this paper Prof. Harkness points out that in observing the Sun with a meridian instrument it is not easy to prevent the solar rays from disturbing the adjustments. Photography, however, seems to afford an escape from this difficulty. A transit-circle might be so constructed that its eyepiece can readily be removed, and a sensitive photographic plate inserted just behind its wire system. Then with the eyepiece in position, stars can be observed, and the instrumental constants determined in the usual way; while at noon a photographic plate can be inserted and an instantaneous exposure will suffice to give an image of the Sun with the transit and declination wires of the instrument imprinted upon it. The position of the Sun's centre relatively to these wires can be measured, and thus an accurate determination of its R.A. and declination can be effected. Applied in this manner Prof. Harkness thinks that photography would probably yield results superior in accuracy to any hitherto obtained by the usual methods.

UNIVERSAL, OR WORLD TIME *.—After discussing the general question of Universal Time in this pamphlet, the author (Prof. Weiss, of Vienna) goes on to speak of the effect of its introduction on Science, particularizing two sciences, Astronomy (including Navigation) and Meteorology. The latter, he points out, is mainly concerned with elements depending on the position of the Sun with respect to the meridian of the place of observation, and it would be impossible to express the basis of meteorological phenomena by means of Universal Time shortly, precisely, and in a generally intelligible manner; for example, the temperature daily maximum occurs shortly after 2 hours after midday. Now in the language of Universal Time, this law would be thus expressed: if we increase the number 14 by the difference of longitude in time of a place from Greenwich when we are east, or diminish it when we are west, then we obtain the time at which in this place the daily temperature is highest. But who, asks Prof. Weiss, would recognize in this statement the above-mentioned simple law? Astronomy would be affected by the introduction of Universal Time much less than Meteorology; as the astronomer records all his observations in his local sidereal time, it is practically indifferent to him to what system of time-reckoning his results are afterwards reduced. Prof. Weiss points out how advantageous it would be

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* Zur Frage der Weltzeit: Sonderabdruck aus dem Astronomischen Kalendar für 1886. Wien, 1886.

were the various Astronomical Ephemerides, which are now computed for different meridians, all computed for a single one. By this means much unnecessary duplication of work might be avoided. For the accomplishment of this reform, however, it is not imperative to wait for the introduction of World Time generally. With regard to the proposal to change the beginning of the astronomical day from noon to midnight, Prof. Weiss remarks that although in civil life midnight is the most convenient epoch for commencement of the day, for astronomers, whose principal work is during the night, this is by no means the case. Again, astronomers are accustomed to count the different kinds of days introduced by them from the upper culmination of the object by whose transit time is determined. Thus the sidereal day begins with the culmination of the First Point of Aries; the true day with the instant when the true, the mean with that when the mean Sun passes the meridian. All that can, under these circumstances, be fairly demanded of astronomers, is that they publish their results, so far as they involve time-data, in that system which is the prevalent one. But Prof. Weiss thinks that they should be allowed to retain their present beginning of the day, supported as it is by considerations of convenience and of logic, until the necessity for a change becomes evident. Although the astronomers of one country might give a great deal of trouble to all the rest by introducing a new time-reckoning, still such a course of action, instead of being a step towards that uniformity which history teaches us is the natural direction in which mankind advances in all such matters, would be a distinctly retrograde step as a disturbance of the present uniform system. Should astronomers come to an agreement with regard to the proposed change in the beginning of the day, Prof. Weiss considers that the change might then be made, but not until steps were taken by which it could be introduced simultaneously throughout the whole astronomical world.

UNIVERSAL, OR WORLD TIME.—The advantages and disadvantages of the proposed new system of reckoning time have been pretty thoroughly discussed from the points of view of the civilian and astronomer; the following treats the matter from the standpoint of the poet:—

"According to the new method of reckoning time, what would become of Thomas Hood's lines on the Ghost of a Negro, which appeared at midday instead of midnight, marking the point so clearly, that all the world can see his meaning when he says—

'Twas twelve o'clock, not twelve at night,
But twelve o'clock at noon;
Because the sun was shining bright,
And not the silver moon.'

"Now suppose, for a moment, the proposed horological inversion had brought noon to some other hour, say seven—a thing possible somewhere or other in the British possessions, as in India, if

Greenwich starts the meridian. Now how, by any possibility, could Hood have discriminated so clearly between day and night under the new system? He might have been understood in his immediate locality if he had put it somewhat as follows—

‘’Twas seven o'clock, and not nineteen,
As seven o'clock was noon;
For overhead the sun was seen,
And not the silver moon.’

"He would, however, have put a footnote to explain that the lines were written for the meridian 75° east longitude, and must, therefore, be modified to suit any other meridian."—*Bath Journal.*

THE MELBOURNE OBSERVATORY.—Mr. Ellery's Report for the year ending June 30, 1885, has recently been received. He remarks that the Great Telescope has continued to do satisfactory work, and may now be considered to be in excellent working order. The first part of the results of the work with the Reflector ('Observatory,' No. 110, p. 204), from its first erection in 1869 to the present date, has at last been published, and Mr. Ellery hopes to follow it up very shortly with other parts, containing plates and descriptions of all the nebulæ hitherto observed. The instrument is chiefly employed in observing the southern nebulæ, but among many occasional observations made with it throughout the year may be mentioned the formation of three regional charts of faint stars following ϵ Orionis, η Virginis, and η Serpentis, at the request of the American Committee for establishing standard magnitudes of faint stars. The work done with the south or north equatoreals (of 8 inches and 4½ inches aperture respectively) comprises observations of Barnard's and Wolff's Comets, measures of α Centauri once a month, besides experiments with Prof. Pritchard's method of stellar photometry. The photoheliograph is also in good order. An alteration has been made in this instrument so as to secure a picture of 8 inches diameter, instead of 4 inches as formerly. So soon as the necessary focal adjustments are completed, the series of larger sun-pictures will be commenced.

The New Transit Circle of 8 inches aperture has been in continuous use since August 22, 1884, and has proved very satisfactory in every respect. In Mr. Ellery's opinion, the instrument throughout reflects great credit upon the makers, Messrs. Troughton and Simms. The meridian work comprises, besides the usual observations of fundamental clock stars, a set of stars selected by Dr. Auwers, for reduction of zone and Transit of Venus observations, stars observed with comets and stars selected from the Melbourne zones. The number of R.A. and Declination observations made with the transit circle was 2287 and 983 respectively. The sixth volume of the 'Results of Astronomical Observations,' giving the results for the years 1876 to 1880 inclusive, was published in February 1885, and has been distributed. A second Melbourne General Star Catalogue containing the meridian results from 1871 to 1884 inclusive is in course of formation. In this Catalogue will be incorporated the whole of the results obtained with the old instrument up to the date of its disuse. We feel sure that our readers will emphatically endorse the words of the Board of Visitors to the Observatory in their Report to the Governor of Victoria, viz.:—"We find that the work of the Observatory in all its branches is being faithfully conducted under Mr. Ellery's direction, and that the efforts made by him and his officers to maintain the honourable position our Observatory has secured among other National Observatories are generally recognized."

THE EAST ANGLIAN EARTHQUAKE OF 1884.—This work of 230 pages, the joint production of Messrs. Meldola and White, is an exhaustive treatise of the destructive calamity which recently visited the county of Essex. The volume is a publication of the Essex Field Club, the members of which have certainly done their utmost towards the collection and preservation of the facts of the occurrence. From the interesting historical introduction we learn that some sixty earthquakes causing structural damage have visited our island; and when we consider that these are culled from nearly 400 shocks since A.D. 103, we incline to think our immunity is not so great as is generally supposed. We are somewhat cheered, however, to learn that only six others can be ranked with that of 1884 in importance. The shock probably originated beneath the villages of Abberton and Peldon and extended northwards to Brigg, 135 miles; S. to Freshwater, 100 miles; E. to Ostend, 100 miles; and W. to Street, 170 miles—covering an area of at least 50,000 square miles. If we remember rightly, it was shown at the last meeting of the British Association that the great circle passing over Stromboli and Heckla also passed Belgium, Colchester, Lincoln, and York, and that at least four fifths of British earthquakes occurred along this line of disturbance. To show that the Essex earthquake occurred during a period of general seismic activity, a list of earthquakes from 1881 is given. The body of the work is necessarily taken up by the descriptive reports. Having a personal acquaintance with the central district, we can warmly commend the accompanying illustrations. The closing chapters treat of the earthquake in relation to geological structure, and maps are appended from which it is clearly seen that the greatest damage occurred over the London Clay districts. In the concluding remarks is a notice of the deflection of the Crowborough Equatoreal. The cause of the shock is attributed to the sudden rupture of deep-seated rocks under a state of strain. The book, which has a good appearance, ought to be in the possession of every Essex man who takes an interest in his county, and it should find favour far beyond that limit as a valuable addition to our too scanty knowledge of seismological phenomena.

The Paris Observatory.—The Annual Report for 1885 of the Director of the Paris Observatory is even more full of interest than usual. The most striking feature is of course the complete and remarkable success of the Brothers Henry in their efforts in celestial photography—a success which has not only made a complete photographic survey of the heavens a possibility, but has brought it within the range of undertakings which we may reasonably expect to see carried out in the near future. We have already referred to these remarkable results ('Observatory,' No. 109, p. 170), but may add now some further particulars. Three instruments have been used for astronomical photography; the first (aperture 0·16 metre), the experimental instrument used in 1884, has been employed in photometric researches, the relative brightnesses of the satellites of Jupiter and the suspected variability of Neptune having been examined. The second is a smaller instrument, aperture 0·11 metre, focal length 0·68 metre, for photographing comets and extended groups of stars. The third is the great instrument (described 'Observatory,' No. 98, p. 219) with which MM. Henry's principal achievements have been obtained. Besides the results summarized in the 'Observatory' for April, Admiral Mouchez mentions that several photographs of the great nebula in Andromeda have been obtained, showing both the *Nova* and the nucleus of the nebula. With a prism of crown-glass of an angle of about 5° before the object-glass, exceedingly distinct photographs have been secured of a number of stellar spectra, including the spectrum of Gore's *Nova* Orionis. Admiral Mouchez remarks on the advantage the photographic method possesses over the eye in the case of faint stars in close proximity to bright ones. The sensitive plate is not dazzled. Two illustrations are given with respect to this department of the Observatory, the first giving a view of the great instrument, the second being a reproduction of the chart of the Pleiades obtained by photography. The report draws a comparison between this chart, obtained in three hours and showing 1412 stars, with the great work on the same group by M. Wolf, which occupied three years of constant labour and gave the places of but 671 stars.

Another very important item of the report is the device of M. Loewy for the study of astronomical refraction. This, as well as M. Gautier's new method of supporting a mercury trough so as to get rid of the effect of earth-tremors, have already been noticed in the 'Observatory' for February (No. 107, pp. 105, 110). The routine work has not suffered by these new departures; in the meridian department the observations of 1885 number 16173; the Lalande stars observed have indeed been less numerous than in preceding years, but this is due to the fact that the revision of the great catalogue is nearly complete. The division errors of the Gambey circle are undergoing investigation, this instrument being the last to be examined. The Garden circle has been employed in observations of circumpolars on M. Loewy's plan; a new flexure apparatus has also been constructed, and 603 observations have been made with it. The equatoreals have been employed for the usual observations of comets, minor planets, and phenomena, the equatoreal of the East Tower being used for the revision of some photographic plates containing faint stars. In the department of calculations, the great Catalogue has been carried so far, that at the date of the report the calculations were complete up to R.A. 8^h, and in process of completion up to 12^h. The Catalogue has been printed up to No. 3800 and copy prepared to No. 4700. The volume of observations for 1882 was passing through the press and that for 1883 was commenced; and of the Mémoires, Vol. xviii. has been distributed, and Vol. xix. was in course of publication.

Amongst the other interesting matter which the report contains may be mentioned a fresh determination of the length at Paris of the seconds pendulum, $-L=0^{m}\cdot99394$; a notice of an investigation by M. Prosper Henry as to the best methods for the measure and reduction of the photographic plates, and a description of a new multiplying seismograph by M. Bouquet de la Grye, which was to come into use in the present year.

PUBLICATIONS OF THE ZONE OBSERVATIONS OF THE ASTRONOMISCHE GESELLSCHAFT.—The first volume of the Kasan Zones ($+75°$ to $+80°$ Decl.) has recently been published by M. Doubiago, who succeeded the late Marian Kowalski as Director of the Kasan Observatory. This volume contains 14,329 observations, that is, about half the total number necessary to complete the projected scheme of having four observations of each star of the zone. The observations were commenced in 1869 and finished in 1877. It will be remembered that Prof. Krueger has already published the Helsingfors zones ($+55°$ to $+65°$) in two volumes. The present volume is therefore the first instalment of a further advance towards the very desirable end of the publication of the zone-observations of the Astronomische Gesellschaft.

THE INFLUENCE OF PHASE ON THE BRIGHTNESS OF THE MINOR PLANETS [*].—Dr. G. Müller, from a number of very careful observations of the brightness of seven of the minor planets (made by means of a photometer on Zöllner's principle attached to one or other of the equatoreals of the Potsdam Observatory), believes that he is warranted in drawing some inferences as to their physical condition. The observations separate the planets into two classes; the first embracing Vesta, Iris, Massilia, and Amphitrite, only showing changes in brightness as the planet approaches opposition, thus resembling Mars in their behaviour; the second class, on the other hand, which includes Ceres, Pallas, and Irene, vary in brightness as they vary in phase, giving thus a light curve like that of the Moon or Mercury.

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[*] Astron. Nachr. Nos. 2724, 2725.

THE ABSORPTION SPECTRUM OF OXYGEN [*].—It will be recollected that M. Egoroff (see 'Observatory,' Vol. vii. p. 22) was able some time ago to identify the great groups A and B in the solar spectrum as due to the absorption of oxygen. Further research has made it probable that the α band is due to the same element. M. Janssen now finds that, under certain conditions, oxygen gives an absorption spectrum composed of shaded bands which are only resolved with great difficulty. At moderate pressures these bands appear much more slowly than the groups of fine lines, but at great pressures they are developed at once; it is even possible to obtain the bands without the groups of fine lines, and *vice versâ*. M. Janssen finds the bands increase in distinctness not in the simple ratio of the density of the gas, but more nearly in the ratio of the square of the density—a fact which explains how it is that they are not visible in the solar spectrum, although the Sun's light has to pass through a much greater thickness of oxygen before reaching us than the light which M. Janssen used in his experiments had to traverse. It will be a matter of great interest to ascertain the positions of these bands, and we trust M. Janssen will soon be able to satisfy us on this point. The shaded bands of stellar spectra of the third type still wait for explanation.

NOTES ON VARIABLE STARS.—Mr. Espin has published the two following circulars in connection with the Liverpool Astronomical Society:—

Circular No. 4.—W Cygni. R.A. (1886·0) $21^{h}\ 31^{m}\ 44^{s}$, Dec. $+44^{\circ}\ 51'{\cdot}0$. The following provisional elements are given:—P=120 to 130 days; V=5·8± to 7·5±. Epoch M=1886 May 19±; m=1886 Feb. 14±.

Circular No. 5.—10 Sagittæ. Observations on June 13, 14, 15, and 16 give $m = \mathrm{M} + 4^{d}{\cdot}4$ instead of $= \mathrm{M} + 5^{d}{\cdot}7 \pm$ as in Circular No. 1. Maxima, July $1^{d}{\cdot}6$; $9^{d}{\cdot}9$; $18^{d}{\cdot}3$; $26^{d}{\cdot}6$. Minima, July $6^{d}{\cdot}1$; $14^{d}{\cdot}4$; $22^{d}{\cdot}7$; $31^{d}{\cdot}0$. The star is four days visible to the naked eye and four days invisible.

PROPER MOTION OF LALANDE 27026 [†].—Prof. Schönfeld points out that this star has a considerable proper motion. From a comparison of Lalande's place (1798·9) with Argelander, Moesta, Yarnall, Cordoba Zones, and Bonn (1886·4), he finds the amount to be in R.A. $-0^{s}{\cdot}065$, and in declination $-0''{\cdot}48$.

A CORRECTION.—In the table of "Maxima and Minima of Variable Stars," in the 'Companion to the Observatory,' pp. 37, 38, R Scuti should be read for R Coronæ in every instance where the latter star is named. The place given for R Coronæ on p. 36 is, however, correct.

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[*] Comptes Rendus, Vol. cii. No. 24.

[†] Astron. Nachr. No. 2734.

Minor Planet No. 258 has been named Tyche by Director George Rümker.

Mr. H. C. Russell, B.A., Government Astronomer at Sydney, has been elected a Fellow of the Royal Society.

Ephemeris for Comet Brooks 1[*].

By Dr. A. Berberich.

Berlin Midnight.	R.A. h m s	Dec. ° ′	Log *r*.	Log Δ.	Brightness.
June 29..	7 42 6	− 7 13·9	9·8418	0·0876	2·9
July 3..	8 11 33	8 43·6	9·8945	0·1128	2·0
7..	8 37 32	9 49·2	9·9405	0·1400	1·4
11..	9 0 24	10 37·4	9·9811	0·1680	1·0
15..	9 20 32	11 13·6	0·0172	0·1957	0·8
19..	9 38 22	11 41·5	0·0498	0·2227	0·6
23..	9 54 15	12 3·9	0·0794	0·2487	0·5
27..	10 8 30	12 22·7	0·1064	0·2734	0·4
31..	10 21 15	−12 39·1	0·1314	0·2969	0·3

The brightness on April 29 is taken as unity.

Elements and Ephemeris for Comet Brooks 3[†].

By Dr. S. Oppenheim.

M. Trépied describes this comet as having on June 2 and 3 the appearance of a very ill-defined nebulosity, with a scarcely visible trace of central condensation, the exact position of which it was very difficult to determine. The comet is very faint.

T = 1886 June 4·627285 Berlin M.T.

$$\left.\begin{array}{ll}\omega \ldots\ldots\ldots\ldots & 175^\circ\ 15'\ 52''\!\cdot5 \\ \Omega \ldots\ldots\ldots\ldots & 47\ \ 55\ \ 58\cdot3 \\ i \ldots\ldots\ldots\ldots & 15\ \ 41\ \ \ 1\cdot9\end{array}\right\}\text{Mean Eq. 1886·0.}$$

Log q ...... 0·1650140

Ephemeris for Berlin Midnight.

1886.	R.A. h m s	Dec. ° ′	Log *r*.	Log Δ.	Brightness.
June 30..	13 8 20	−14 30·6	0·1783	9·9632	0·66
July 2..	13 13 28	15 37·4			
4..	13 18 40	16 42·6	0·1825	9·9767	0·61
6..	13 23 57	17 46·3			
8..	13 29 17	−18 48·3	0·1872	9·9910	0·56

The brightness on May 23 is taken as unity.

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[*] Astron. Nachr. No. 2731.

[†] Ibid. No. 2735.

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CONTENTS.

Page
the Liverpool Astronomical Society ... 273

—

Small Telescopes. By W. F. Denning, F.R.A.S. ... 274
Second Comet, 1886. By E. E. Barnard ... 278
Notes. By W. F. Denning, F.R.A.S. ... 279

pondence:—

nian Comets. By W. H. S. Monck, M.A., F.R.A.S. ... 279
le Comets. By W. C. Evans, M.A., F.R.A.S. ... 282
met of 1366. By W. T. Lynn, B.A., F.R.A.S. ... 282
y's Comet at its Appearance in 1759. By W. T. Lynn, B.A., F.R.A.S. 284
's Hypothetical Satellite. By J. R. Sutton, F.R.A.S. ... 286
ge. By the Rev. Edward Bruce Kirk ... 286
e Proper Motion of Armagh 462 = Lalande 8808. By J. G. Porter ... 287
y Motion in a faint Star. By J. G. Porter ... 288
ral Time. By T. W. Backhouse, F.R.A.S. ... 288

:—

Solar Eclipse of 1886, August 29.—The Cape Observations of the Great
Comet 1882 II.—Three Letters by Kepler.—Kam's Star Catalogue.—
Schulhof's Researches on the Orbit of the Comet 1873 VII. (Coggia-
Winnecke).—The Strassburg Observatory.—Black Transit of Jupiter's
Fourth Satellite.—Observations of the Companion of Sirius.—Method
of Correcting for Differential Refraction in Declination.—The Lick
Equatoreal.—Micrometrical Measures of Gaseous Spectra under High
Dispersion.—Editorial Notes ... 289-296

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Amongst the contributors to 'The Observatory' in 1885 were Professors Asaph Hall, Holden, Hough, Pickering, Pritchard, and Young; Dr. Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs. Barnard, Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"—*Bulleti Astronomique* (organ of the Paris Observatory).

CONTENTS OF No. 112.

Page

Meeting of the Royal Astronomical Society on June 11 241

Articles:—

Meteor Notes. By W. F. Denning, F.R.A.S. 254

Correspondence:—

The Nomenclature of the Constellations near the South Pole. By W. T. Lynn, B.A., F.R.A.S. 255
The Density of Algol. By J. E. Gore, M.R.I.A. 257
The proposed Change in the Astronomical Day. By Capt. W. Noble, F.R.A.S. 258
Previous Visits of Periodic Comets. By W. H. S. Monck, M.A., F.R.A.S. ... 259

Notes:—

Royal Observatory, Greenwich.—The University Observatory, Oxford.—The Flexure of Meridian Instruments.—Universal, or World Time.—The Melbourne Observatory.—The East Anglian Earthquake of 1884.—The Paris Observatory.—Publications of the Zone Observations of the Astronomische Gesellschaft.—The Influence of Phase on the Brightness of the Minor Planets.—The Absorption Spectrum of Oxygen.—Notes on Variable Stars.—Proper Motion of Lalande 27026.—A Correction.—Minor Planet.—Editorial Note 260-272

Ephemeris of Comet Brooks 1. By Dr. A. Berberich 272
Elements and Ephemeris for Comet Brooks 3. By Dr. S. Oppenheim 272

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 113. AUGUST. 1886.

Liverpool Astronomical Society.

The fifth Annual General Meeting for the election of officers was held on July 17, at the Association Hall, Mr. James Gill occupying the chair. The annual report on the state of the affairs of the Society was read by Mr. R. C. Johnson, F.R.A.S., who acted as Secretary *pro tem.* Since the last annual meeting there had been an increase of 21 Members, making a total of 257. Twenty-eight papers had been read during the session, and published in the Society's Journal. More than a thousand observations of variable and red stars had been made by the Rev. T. E. Espin. The observations on variable stars had been communicated to Prof. Pickering, and published in the 'Proceedings of the American Academy of Arts and Sciences.' A list of 109 new red and orange-red stars had also been published in the 'Monthly Notices' of the R. A. S. The magnitudes of 524 stars had been deduced from photographs taken with the stellar camera, and were now ready for publication. The retiring President, Mr. Isaac Roberts, had also undertaken photographic work, and those who had examined the magnificent stellar photographs of the Brothers Henry would understand the importance of this branch of the science. The instrument employed by Mr. Roberts was a reflecting telescope of short focus and 20 inches aperture. Stars of even small magnitudes had been photographed very distinctly in fifteen minutes, whereas the exposure recommended by Admiral Mouchez was from one to three hours. Much, however, depended upon the state of the atmosphere and other conditions with which at present we were but little acquainted. As an example of this uncertainty, the companion to Polaris had been in one instance photographed in four seconds, whilst on another plate it did not appear after an exposure of sixteen minutes. More than 200 photographs had been taken from the Pole down to 69° N. decl. Amongst the difficulties to be enumerated were small specks upon the film, which were hard to distinguish from stars when viewed through a microscope.

The balloting papers were then opened by the scrutineers, and the following officers were declared duly elected :—*President*, Rev. T. E. Espin ; *Vice-Presidents*, W. F. Denning, W. S. Franks, J. E. Gore, James Gill ; *Special Observer*, Rev. T. E. Espin ; *Secretary* and *Treasurer*, W. H. Davies ; *Council*, Miss E. Brown, Messrs. G. Calver, W. H. Davies, jun., T. G. Elger, S. M. B. Gemmill, F. H. Masters, J. M. Offord, Rev. T. Perkins, John Stead, K. J. Tarrant, W. L. Stubbs, and H. Thomas.

A vote of thanks to the retiring officers was proposed by Mr. W. H. Davies, seconded by Mr. W. S. Franks, and carried unanimously, when the Meeting adjourned until October 11.

Large v. *Small Telescopes.*

PROFESSOR YOUNG's further remarks in the 'Observatory,' No. 107, p. 92, and in the 'Sidereal Messenger' for January 1886, call for some reply. Moreover the subject is one of abiding interest.

While recognizing the value of practical efforts to test the question at issue, we can hardly admit results obtained by contracting the aperture of a large refractor. 9 inches of the centre of the large Princeton lens is not equivalent to a good 9-inch O. G. I do not know the thickness of the Princeton 23-inch, but the average of the central 9 inches must be enormously greater than the average thickness of an ordinary 9-inch glass. Hence the latter will pass far more light and give superior definition and other advantages because of more perfect figure and greater facility of manipulation. The mere contraction of a large lens does not eliminate all the evils common to it. The cone of light may be limited to the required degree, but there are other conditions less tractable. To be perfectly fair we must institute comparisons with glasses actually differing in size. In mentioning this I do not forget that Prof. Young has already effected some legitimate trials by employing the 9½-inch Gaussian lens belonging to his observatory.

In your Journal for March 1885, p. 79, Prof. Young will see that the late Dr. Robinson of Armagh is mentioned as saying, "the effect of air disturbance, in reflectors, is at least as the cube of their diameters." Dr. Robinson's conclusion * was not applied to refractors. It would seem from Prof. Young's remarks that the

* His words are as follows:—"A stream of heated air passing before the telescope, the agitation and hygrometric state of the atmosphere, and any difference of temperature between the speculum and the air in the tube, are all capable of injuring, or even destroying definition, though the speculum were absolutely perfect.

"The effect of these disturbances is, in reflectors, at least as the cube of their apertures ; and hence there are few hours in the year when the 6-foot can display its full powers."—*Observations of Nebula and Clusters of Stars made with the 6-foot and 3-foot Reflectors at Birr Castle*, by Lord Rosse. Appendix. Scientific Transactions, Royal Dublin Society, August 1879.

effect of atmospheric undulations is not nearly such a serious drawback in the case of a large refractor. In reflectors the open tube admits disquieting air-currents (and the radiation of heat from the observer's body must also have an effect), which renders these instruments more sensative to such hindrances than refractors. Within the tube of reflectors there is a duple passage of the light rays—first parallel to the speculum, then convergent to the flat. In refractors there is but a single passage of convergent rays.

Prof. Young says, I have "quoted against the great telescope at Washington the small amount of detail shown upon certain drawings of Mars by Prof. Harkness. But it is known to many that other drawings made about the same time by a junior observer, and since then communicated to Dr. Terby at Louvain, exhibit everything that appears in the best maps of Schiaparelli' ('Sidereal Messenger,' Jan., p. 1). This is rather astounding. A chart of Mars is forwarded from the U. S. Naval Observatory to the Royal Astronomical Society, and the society go to the expense of engraving it. Englishmen naturally accepted it as a sample of what the great telescope was capable of doing; they had no idea the astronomers at Washington would send over a very deficient piece of work. But it now leaks out that at nearly the same period another series of drawings, far more comprehensive in detail (and more satisfactory, as showing the real powers of the large Washington lens), were made by a more successful observer, and these were utilized for another purpose!

Recent advances in areography contain another glaring case of the relative inefficiency of large telescopes. Compare the twenty drawings of Mars, made in January, February, and March 1884, with an $8\frac{1}{2}$-inch reflector, powers 250 to 400, in the Memoirs of the R. A. S. (vol. xlviii. part ii. 1884), with thirteen drawings made in March and April 1884, with a 3-feet reflector, powers 144 and 216, published in the Scien. Trans. of the Royal Dublin Society for March 1885. Of course the smaller telescope has far and away the best of it. The magnifying-power utilized with the 36-inch mirror was generally 144, with the $8\frac{1}{2}$-inch never less than 250!

In judging of the capacity of telescopes of different apertures we cannot go on a safer basis than by results. Though several of the large refractors have now been mounted long enough to give us the proofs of their oft-asserted prowess in regard to planetary definition, new discoveries are entirely wanting. No details have been announced on the major planets which cannot be readily observed in small instruments. Indeed, recent work has proved that notwithstanding the high degree of excellence which improved methods have wrought in large glasses they are still practically out of the field. Their powers seem exercised to eliminate certain formations seen in smaller appliances, and thus they cut down rather than extend our knowledge. How is this? The large telescopes are either faulty in definition (glare and rolling air-currents eradicating features otherwise visible), or the observers themselves are to some extent blamable. It must be one thing or the other.

In June 1874, the late Mr. Lassell wrote: "There are formidable and, I fear, insurmountable difficulties attending the construction of telescopes of large size . . . . . These are primarily the errors and disturbances of the atmosphere and the flexure of the object-glasses or specula. The visible errors of the atmosphere are, I believe, generally in proportion to the aperture of the telescope. . . . . Up to the size [referring to an 8-inch O. G.] in question seasons of tranquil sky may be found when its errors are scarcely appreciable, but when we go much beyond this limit (say to 2 feet and upwards) both these difficulties become truly formidable. It is true that the defect of flexure may be in some degree eliminated, but that of atmospheric disturbance is quite unassailable. These circumstances will always make large telescopes *proportionately* less powerful than small ones; but notwithstanding these disadvantages they will on some heavenly objects reveal more than any small ones can." Mr. Lassell's last sentence refers to "delineations of the forms of the fainter nebulæ" to "seeing the inner satellites of Uranus, the satellite of Neptune, and the seventh satellite (Hyperion) of Saturn;" he mentions that, when at Malta, he "saw in the 2-foot equatoreal, with a power of 1027, the two components of γ^2 Andromedæ distinctly separated to the distance of a neat diameter of the smaller one. Now no telescope of anything like 8 inches diameter could exhibit the star in this style." These remarks of Mr. Lassell will have our hearty concurrence. It is, however, impossible to say what objects may not be reached by an 8-inch glass in thoroughly good hands. Titania and Oberon were alleged to have been seen* early in 1876 with a 4·3-inch lens, power 240, and in October 1877 the only known satellite of Neptune was glimpsed* with the same instrument. The outer satellite of Mars was seen* in a 7-inch O. G. in September 1877. The great capacity of Dawes in detecting faint comites and other objects is well known, so also the marvellous powers of Heinrich D'Arrest in the realm of nebulæ. Are such optical feats to be explained by personal attributes, such as acute vision, aptness of method, combined with great persistency and a determination to succeed? The *assumed* reach of the instruments employed by such observers has very little significance. Arbitrary limits cannot be assigned, because the powers of a telescope depend in a very great measure on the powers of the observer. The two must be taken collectively.

Yet it appears to me impossible to wholly resist the corroborative evidence of Profs. Young and Hough and Mr. Green that even on bright planets their large instruments possess an unquestionable advantage. Here are men with long experience, perfectly unbiassed, and having every means of critically testing the question on its merits, and they concur that large apertures are superior, sometimes much superior, to small ones. Testimony of this sort cannot be lightly set aside. The facts obviously involve a singular contradiction. But we can scarcely admit that, valuable as they are, the individual experiences just quoted veto the mass of published results which are all in favour of the small instruments. Perhaps Prof. Young has justly referred the primary cause of the difficulty to abnormal powers of sight in certain persons. We must remember that for every observer using 18 inches, or upwards, of aperture there are more than 100 working with lenses or specula from about 5 to 12 inches; hence we may expect many exceptional instances of cuteness amongst the latter. Atmospheric conditions in its various influences must also play an important part. The success of men like Dawes and Schiaparelli, who outstrip their contemporaries and with small instruments achieve phenomenal results, is to be ascribed to keenness of vision and to that natural avidity and pertinacity uniformly characteristic of the best observers. This may explain the fact why the eminent director of the Milan Observatory sees more detail on Mars, through a refractor of only 8 inches aperture, than is revealed to ordinary eyes with the finest instruments extant. It is a great fallacy to conclude that an object shown in a small telescope is a false appearance because it cannot be distinguished in a large one*. There has been a growing tendency of late years to controvert results resting on slender testimony, and perhaps those who have the command of large instruments are a little apt to feel dubious of the successes justly claimed for small ones. When the "canals" on Mars were first announced the idea was ridiculed in certain quarters; but the tendency of subsequent researches in the same direction has gone to substantiate these features. Step by step the greater instruments appear to be grasping the complicated structure of delicate markings so obvious to Schiaparelli with his relatively diminutive glass! Recent experiences in regard to certain disputed forms on Jupiter have also proved the reliable nature of the work done by small telescopes.

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* In these cases the angles of position &c., computed for the real objects, closely agreed with the estimated places of the suspected objects observed. Which are we to marvel at most, the remarkable fortuitous coincidences of position, or that the observations were really effected?

In conclusion, I would express the hope that those who have the means of further investigating this question will do so, as it is one of vital interest and importance to practical astronomy.

Bristol, February 10, 1886. W. F. Denning.

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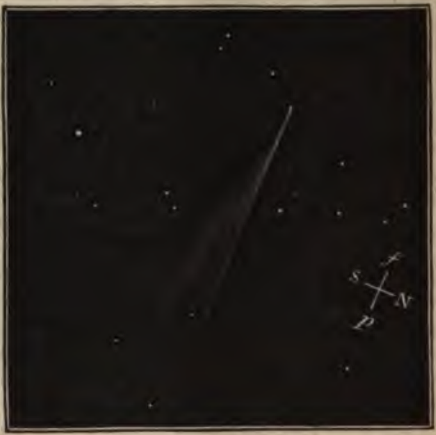
* Prof. Asaph Hall, who has done more important work with a large instrument than any other living observer, remarks (in that spirit of magnanimity and impartialness which we cannot fail to appreciate):—"There is, perhaps, too much scepticism on the part of those who are observing with large instruments in regard to what can be seen with small ones."—*Observatory*, vol. viii. p. 174.

Brooks' Second Comet, 1886.

This comet was first observed here on the morning of May 2. The head was remarkably slender and bright. Had any nucleus existed it would have been hard to distinguish it from the head itself. The tail was very bushy in form and roughly $\frac{1}{4}$° long. But momentary glimpses of the comet were obtained through breaks in drifting clouds; but it was easy to see that it was in rapid motion towards the north-east. On the 3rd (A.M.) there was no sensible change in the appearance of the comet, except that the tail appeared slightly more diffused.



Brooks' 2nd Comet, 1886.
Telescopic view: 6-in. refractor, power 60.
May 7, 1886, 15^{h} 0^{m} Nashville M.T.

May 8 (A.M.), the comet was sensibly less bright, the diminution of light was principally in the head, which had lost perhaps half its brightness; the tail appeared as bright as when first observed, perhaps. It was noticeable that the following side of the tail was decidedly the brightest and somewhat convex to the north.

This is certainly the most singular-looking telescopic comet that I have yet seen; it was indeed a perfect miniature of the naked-eye appearance of a great comet. Thinking the telescopic appearance worthy of record, I herewith give a drawing of this comet made at the telescope on the morning of May the 8th at 3^{h} Nashville civil time; six-inch Cook equatoreal, power 60.

Vanderbilt University Observatory,
Nashville, Tenn., U. S. A.

E. E. Barnard.

Meteor Notes.

Between June 28 and July 6 I counted 92 shooting-stars in 16½ hours of observation. The best shower was from 294° +39°, 6° S.S.W. of δ Cygni, and the radiant was very sharply defined from about 10 meteors moving slowly in short paths. This stream has been previously noticed by several observers, and apparently it occurs both in July and August. The average of 8 radiants gives the centre at 292°·1 +42°·6, but it is doubtful whether we are justified in associating all the positions included in the mean. The large fireball of 1878 July 29 was directed from about 290° +42° ('Monthly Notices,' 1879 Feb., p. 285), so that it may have had its origin in the same system.

Among the other radiants found during the above period was one at 219° +72° near β–γ Ursæ Minoris, which appears to be a new display for the epoch. Additional showers were seen from 21° +23° and 339° +31° (swift, streak-leaving meteors), 316° +46° (short, quick meteors), and 303° +24° (rather swift meteors). The latter falls very close to one of the radiants I found between May 28–July 4 last at 304° +22° ('Observatory,' 1886 July, p. 254); and in 1885, July 8–13, I had seen a few meteors from 303° +24° ('Nature,' No. 818, p. 342), which is undoubtedly the same. I have also obtained evidence this year of many other showers of extremely feeble character. With but few exceptions, however, the paths registered were very various, so as to seem indiscriminately projected upon the firmament with little evidence of divergence from definite points. This of course results from the very tenuous nature of the streams encountered and the large number of such streams distributed over the sky.

Bristol, 1886, July 16. W. F. Denning.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Companion Comets.

Gentlemen,—

The existence of what I may term companionship among comets has been more than once noticed in the columns of the 'Observatory' as well as elsewhere. Thus the similarity of the elements of the three great comets of 1843, 1880, and 1882 was too obvious to escape notice, though it is certain that all three could not have been identical, and it is not probable that any two of them were so. Among other comets thus connected are two at least of the 70-year periodicals, and comets which appeared in the years 1827, 1852, and 1877, as noticed by Professor Kirkwood in the 'Observatory' for the latter year (see Group V.). Such connected comets, however, are, I think, more numerous than has hitherto been supposed, whatever explanation may be given of their connection. Three such explanations (none of them, I believe, new) occur to me. First, that the comets formed part of the same original comet. The separation of a comet into two parts was observed in the case of Biela's comet in 1846; it is recorded of the great comet of B.C. 370; and the great comet of 1882 exhibited decided traces of this tendency. We had, moreover, an instance of a double comet in 1860 and also in that observed in 1872 by Pogson, which could scarcely have been Biela's pair. Here there is one explanation of companionship which undoubtedly applies in some cases, though it may not be wide enough to cover all. A second explanation would be the existence of comet-systems in space, which our knowledge of star-systems renders highly probable. A third might be derived from Mr. Proctor's theory of ejection, inasmuch as the disturbing force would not probably spend itself in a single outburst, and two or more comets having their origin in the same disturbance might be expected to present considerable similarity of elements. In this latter case, if the orbits were nearly parabolic their common direction might enable us to determine from what star a given family of comets had been ejected. I am not aware that Mr. Proctor has as yet done much in this line. It would afford some confirmation of his theory if the paths of some of our great parabolic or nearly parabolic comets were shown to point towards some prominent fixed star.

I proceed to give a few examples of what seem to me to be instances of companionship among comets. As to the two first in my list, the inclinations of the orbits are so great that a slight tilting would convert a retrograde into a direct motion. In all the other cases the motion of the companions is in the same direction.

		π.		☊.		i.		q.	μ.
		°	′	°	′	°	′		
I.	Comet 1871 i.	141	49	279	18	87	36	0·6543	Direct.
	Comet 1871 iv.	147	2	264	30	81	56	0·6944	Retrograde.
	Comet 1871 ii.	115	43	211	56	78	0	1·0835	"
	Comet 1865 i.	141	15	253	3	87	32	0·0260	"

(The last of these comets may possibly be a return of the comets of 1490 and 1677. The enumeration, even with these additions, is moreover probably incomplete.)

		π.		☊.		i.		q.	μ.
		°	′	°	′	°	′		
II.	Comet 1857 iii.	249	37	23	40	58	59	0·3675	Retrograde.
	Comet 1857 v.	250	21	14	46	56	18	0·5651	"

(These comets probably belong to a numerous family, and shade almost imperceptibly into Group V. I would mention the comets of 1743, 1790 iii., 1808 iii., 1825 i., and 1868 ii.)

		π.	☊.	*i.*	*q.*	μ.
		° ′	° ′	° ′		
III.	Comet 1863 i.	191 22	116 55	85 22	0·7947	Direct.
	Comet 1863 vi.	183 8	105 1	83 18	1·3131	,,
	Comet 1860 iii.	161 32	84 40	79 18	0·2929	,,
	Comet 1879 v.	202 38	87 11	77 8	0·9896	,,
IV.	Comet 1854 ii.	213 47	315 26	82 22	0·2770	Retrograde.
	Comet 1854 iv.	272 58	347 48	71 8	0·6475	,,
	Comet 1858 iv.	226 6	324 21	80 28	0·5784	,,

V. To the Comets 1827 ii., 1852 ii., and 1877 ii., noticed by Professor Kirkwood, I would add the comets 1830 ii. and 1845 iii. The latter has been identified with the comet of 1596, which may perhaps be the origin of this system.

		π.	☊.	*i.*	*q.*	μ.
		° ′	° ′	° ′		
VI.	Comet 1845 i.	91 9	336 44	46 50	0·9051	Direct.
	Comet 1846 viii.	98 35	4 41	49 41	0·8306	,,
	Comet 1854 v.	94 20	324 34	40 59	0·8001	,,
VII.	Comet 1861 iii.	173 30	145 6	41 57	0·8391	Retrograde.
	Comet 1864 i.	190 10	175 11	44 56	0·6140	,,

(The latter comet bears a strong resemblance to Comet 1822 i.)'

This list could be easily enlarged, and I may perhaps trespass on your space again in relation thereto. Without any enlargement, however, I think the number of coincidences within the short period to which it refers is much greater than chance will account for. But I may add that there are comets whose elements strongly resemble those of known periodic comets, and whose periodicity may therefore probably be inferred. Thus—

		π.	☊.	*i.*	*q.*	μ.
		° ′	° ′	° ′		
VIII.	Westphal's Comet, 1852	43 12	346 13	40 58	1·2510	Direct.
	Comet 1860 ii.	50 16	8 56	48 13	1·3083	,,
IX.	Brorsen's Comet, 1846	116 28	102 37	30 57	0·6500	Direct.
	Comet 1860 iv.	111 59	104 14	28 14	0·9537	,,
X.	Comet 1785 i.	109 51	264 12	70 14	1·1434	Direct.
	Tuttle's Comet, 1790	111 44	267 8	56 58	1·0632	,,

In the last three cases the known periods of the comets in question exclude the possibility of identity, but community of origin is suggested. Several of the comets of short period, too, exhibit a family likeness among themselves which can hardly be attributed to their capture by Jupiter, unless they previously formed members of a system. To this last-mentioned system the comet of 1678 seems to belong.

Truly yours,
W. H. S. Monck.

Dublin, 1886, July 12.

Periodic Comets.

GENTLEMEN,—

I have no intention of commenting on the identity of various comets suggested by Mr. Monck, but the doubt expressed by that gentleman as to the correctness of the period assigned by the 'Annuaire' to Tempel's comet of 1867 is certainly not well founded. Not to speak of the other comets, of which probably something similar may be said, there is a group including (besides Tempel's comet) Brorsen's, Winnecke's, and D'Arrest's at least. These comets undergo enormous perturbations, their period oscillates about twice that of Jupiter, in fact their period is no doubt commensurable therewith, only differing from the double of Jupiter's by periodic quantities. Without entering upon the mathematical demonstration of this from the theory of perturbations, observation shows that μ (the diurnal motion of Brorsen) has changed from 637″ to about 650″ (the latter number is evidently a maximum), and the possible variation is probably from about 550″ to 650″. Winnecke in 1819 had $\mu=631''$; in 1858 $\mu=638''$; and now it is probably about 600″; between 1819 and 1858 μ attained its maximum. In Tempel's comet μ has varied from 628″ in 1867 to 545″ at present. The oscillation is probably from 670″ to 530″. The μ of D'Arrest has varied, since the comet has been under observation, from about 556″ to 531″; the oscillation about the same as Temple's: the latter number is probably a minimum. About the minima and maxima of μ the values of that quantity, as might be expected, change but little in accordance with the circumstance that then the distance of the comet from Jupiter is large, whilst the reverse is the case when the value of μ is near 600″.

48 Springdale Road,
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W. C. EVANS.

The Comet of 1366.

GENTLEMEN,—

In his letter to you of the 14th of June (printed in the July number of the 'Observatory,' p. 259), Mr. Monck suggests that "the comet of Faye is possibly identical with that of 1366," but adds that it is difficult to feel confidence on the point because Mr. Chambers, in his Catalogue of Comets, "omits to state whether the motion of the latter comet was direct or retrograde."

The elements given by Chambers are those computed by the late Prof. Peirce, which were published in the American Almanac for 1847, and are quoted by Hind ('The Comets,' p. 127), by Cooper (Markree Catalogue of 'Cometic Orbits,' p. 16), and by Carl ('Repertorium der Cometen-Astronomie,' p. 41). Hind and Cooper leave the column for motion blank, in which they are followed by Chambers; Carl, however, assigns it as "direct." Finding that there was no copy of the American Almanac for the year in question in the libraries either of the R. A. S., the R. S., or the

British Museum, but knowing that the motion of the comet of 1366 was generally supposed to be retrograde (like that of Tempel's comet of 1866 and of the Leonid meteors, with which its connection is now so well established), I wrote to Dr. Hind (who has a paper on the probable identity between the comets of 1866, 1366, and 868, in the 'Monthly Notices,' vol. xxxiii. p. 48), requesting him kindly to furnish me with the results of his own calculation of the orbit of the comet of 1366. In his reply (which is dated Cambridge Park, Twickenham, 1886 July 12) he writes:—

"The best orbit I found out of several computed gave—

T = 1366 Oct. 21·455, G.M.T.

$$\left.\begin{array}{lr} \pi \ldots\ldots\ldots & 48^\circ\ \ 4' \\ \Omega \ldots\ldots\ldots & 217\ \ 25 \\ i \ldots\ldots\ldots & 27\ \ 37 \end{array}\right\}\text{Equinox of 1366.}$$

$\log q \ldots\ldots\ 9{\cdot}99114$

Retrograde.

The inclination was the most uncertain element, and I thought a smaller one might prove better.

"Peirce sent me a copy of the American Almanac, 1847, containing his orbit for this comet; and I separated his article from it, and placed it amongst my papers, but I have not been able to find it. However, in my Common-place-book of 1847 I find all five orbits which he gave from his own calculations for Equinox of 1850, referring to ancient comets, are copied direct from the Almanac; in the case of the comet of 1366 I have noted "direction of motion not given," and though it is so long since, I distinctly recollect being surprised that it should have been omitted. It was probably a typographical slip. Carl's mention of *direct* motion is a gratuitous addition of his own. The comet of 1366 was *retrograde* according to the Chinese observations, or rather calculation founded upon them."

I have thought it would be interesting to send you all these particulars, on account of their bearing upon the question of the identity of the comets of 1366 and 1866 (of which apparently little doubt can remain). The great difference between the perihelion distances of the comet of 1366 and of Faye's periodical comet is, I apprehend, quite sufficient to negative any possibility of identity between these. Dr. Hind's interesting letter shows also that their motions were in opposite directions. He adds, I should remark—"The track of the comet of 1366 is very well represented by the elements (Oppolzer's) of comet of 1866, carried back to that year." It will be noticed that the perihelion distance of comet of 1366 from Dr. Hind's elements above is 0·980: that of the comet of 1866, from Oppolzer's, is 0·977. The perihelion distance of Faye's comet (which was observed in 1843, 1851, 1858, 1865, 1873, and 1880) exceeds the mean distance of Mars, and amounts to 1·70.

Another point is worth mentioning whilst on this subject. It is well known that the path of the comet of 1366, as described by the Chinese, was long a puzzle to astronomers, and some have suggested that their accounts refer to *two* comets moving nearly along the same path. Mr. Williams, however (the late respected Assistant Secretary of the R. A. S.), in his 'Chinese Observations of Comets,' points out (p. 73) that "if the narrative in the original be carefully examined it will be found to divide readily into two distinct portions, the one giving the course of the comet through the S.D. [Stellar Division], and the other that through some of the asterisms in that course." In Dr. Hind's letter to me he states that he feels sure that Williams is "perfectly correct" in this view, and adds that the latter, in a letter written to himself, subsequently to the publication of his book, informed him that he had closely examined the question again, with the result that he was more fully confirmed in his explanation. There is therefore no reason whatever to suppose that two comets followed each other in 1366 nearly in the same path.

Yours faithfully,
W. T. Lynn.

Blackheath, 1886, July 14.

P.S.—It is somewhat singular that in Mädler's translation (p. 145) of Dr. Hind's book on 'The Comets,' the column for direction of motion is filled up for this comet as "D"; possibly Dr. Carl may have copied it therefrom. The column in question is properly left blank in Encke's edition of Olbers's well-known treatise on the calculation of cometic orbits. In the catalogue contained in the 'Vade Mecum,' the motion is given as "direct"; the elements are stated to be those calculated by Peirce, but the longitudes of the perihelion and of the node differ (each by 7°) from the values given in the 'American Almanac' for 1847.—W. T. L.

Halley's Comet at its Appearance in 1759.

Gentlemen,—

The mistake made by Sir John Herschel in asserting (by implication *) that Palizsch, when he re-discovered Halley's Comet on Christmas Day, 1758, did so without the help of a telescope, has often been commented on, but I have not seen the cause of it pointed out in any books on astronomy. It is, however, easy to explain, being evidently taken from the account in the 'Histoire de l'Académie royale des Sciences' for 1759. As the early volumes of that series are rare, it may interest some of your readers to give a few quotations from the account in question. Speaking of the appearance of the comet before the perihelion passage, we read (p. 157):—"La grandeur apparente de cette comète est la seule chose dont il nous reste à parler, pour rendre à-peu-près complète

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* 'Outlines of Astronomy,' 10th edition, p. 598, note:—"nearly a month before any of the astronomers who, armed with their telescopes, were anxiously watching its return."

l'histoire de son apparition : quoiqu'un Paysan de Saxe ait aperçu cette Comète à la vue simple le 25 Décembre 1758, comme nous l'avons dit, elle étoit alors fort petite, et le 21 Janvier suivant, lorsqu'elle fut observée à Paris, elle étoit plus éloignée de la Terre, plus difficile à voir, et on ne la distinguoit point à la vue simple ; elle augmenta ensuite peu-à-peu, et son noyau devint plus brillant jusqu'au 25 Janvier ; de-là on continua de la voir à-peu-près de même qu'une Etoile de la septième grandeur, jusqu'au 13 de Février, où finit sa première apparition."

The assertion that Palizsch saw the comet on Dec. 25, 1758, with the naked eye ("à la vue simple") is also made at the earlier place referred to (p. 144), where, after mentioning Palizsch's discovery, as well as the facts that the comet was observed afterwards by Dr. Hofmann at Dresden (on December 28), and by an astronomer at Leipzig (who observed it on Jan. 18, 1759, and wrote an anonymous memoir about it, which was published on January 24), the writer goes on to say :—"M. de l'Isle, dans sa seconde Lettre aux Auteurs du Journal des Savans, en date du 16 Juin 1759 (vol. d'Août 1759) s'étonne avec raison qu'un paysan ait découvert cette Comète à la vue simple, sans la chercher, et sans en avoir la moindre idée, un mois* plus tôt que M. Messier qui l'avoit cherchée plusieurs fois avec un télescope de quatre pieds et demi, dans le lieu même vers lequel elle devoit être ; on ne peut attribuer cette singularité qu'à l'avantage qu'on eut en Saxe de jouir du plus beau temps, lorsqu'on étoit à Paris dans les brouillards. Il faut aussi convenir qu'un homme dont la vue est perçante et qui voit d'un coup d'œil une grande étendue du ciel, a de l'avantage sur un Astronome qui n'examinant à la fois, dans son télescope, qu'une très-petite partie du ciel, peut manquer très-souvent le point où se trouve précisément la Comète ; d'ailleurs elle étoit un peu plus près de la Terre le 25 Décembre qu'au commencement de Janvier."

I need hardly remark now that Palizsch has been long since deprived of this wonderfully piercing sight, it having been pointed out by Bode, in the 'Berliner Jahrbuch' for 1828, that he in reality made use of a telescope of 8 feet focal length, that he was engaged in a search for the comet (with the expected advent of which he was acquainted) whilst also making observations of Mira Ceti, near which the comet then was ; and that although a "paysan" in the sense of being an agriculturist, he was a man of education and of scientific tastes in other departments as well as astronomy. But we may take part in the writer's astonishment (even in that day) that, although the comet's appearance had been mentioned in print in Germany in the month of January, this remained a secret for two months to the astronomers of Europe, and that no one out of Germany saw it, excepting Messier at Paris, until it was seen on the 27th of March (fifteen days after the perihelion passage) at Lisbon and Bologna, five days before Messier publicly announced that it had been again seen at Paris.

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* Not quite, it will be remarked ; M. Messier's first observation was made on the 21st of January.

Several of Bradley's observations of this comet are given in Rigaud's 'Life and Correspondence of Bradley,' all in the month of May, 1759, and it is stated that there is no doubt several others must have been made and were lost. But it is added that one other was preserved by Lalande, and printed in the Memoirs of the Academy for 1759. The article in which this is contained commences that volume, and Bradley's observation (the date of which is not mentioned by Rigaud) is given at p. 36. It was made on the 1st of May, and is therefore the first of Bradley's observations of the comet that have been preserved. Reference to the 'Philosophical Transactions' for 1759 will show that both Dr. Bevis in London (at Mr. Short's) and Mr. Munckley at Hampstead also observed the comet on that and the following day, and saw it the night before (April 30th) without being able to make an observation. These are all the English observations, so far as I am aware, that were made.

In conclusion, I should like very much to ask your German readers and correspondents whether the author of the Memoir published at Leipzig on January 24, 1759, referred to above as anonymous, can be traced; and whether any copies of the Memoir itself are in existence.

Yours faithfully,
W. T. Lynn.

Blackheath, 1866, May 25.

Algol's Hypothetical Satellite.

Gentlemen,—

Mr. Maxwell Hall's paper in your June issue, on the 'Density of the Sun compared with that of Algol,' was very interesting and well worthy of perusal. But does it seem a fair inference that the components of Algol are both gaseous? It would seem more likely that instead of being "undoubtedly dealing with masses of gas," we are rather, in the case of Algol's hypothetical satellite, dealing with a dense meteoric swarm—that is of course if the observed variations of light are caused by some dark body or mass. For surely if the two components were so nearly equal (according to Mr. Hall's figures for the total diminution of light, and taking the respective densities to be the same, we find the volume of one to be to that of the other as 1 : ·79 approximately) we should scarcely expect to find the one so dark and the other so relatively bright. Experience goes to show that as gaseous bodies get dark they cool and contract; and if this process goes on, or has gone on, in Algol's system as elsewhere, then it follows that the mass of the satellite would be, when its size and increased density are considered, much greater than that of its own luminary—a state of things calculated to kindle afresh the waning fires of "Zetetic" (?)

Astronomy. (Or if this satellite gives *some* light, as it ought to do being gas, then it would be much larger than we could otherwise assume.) But there seems no reason why Algol's diminution of light should not be caused by meteoric matter. In the first place, it lies close to the galaxy; and this would seem to be made up for the most part of bodies which would cut but a very insignificant figure beside our own asteroids. Moreover, Argelander has concluded "that the period of Algol is not quite constant"[*], and, further, "its period .... seems to have diminished from that which it had in 1782"[†]. Both curious results if the satellite theory be true.

Leighton, Beds. J. R. Sutton.

δ *Cygni.*

Gentlemen,—

On the night of June 26th I had a peculiarly fine view of this interesting double. The air was cool, still, and clear, and I tried various powers, both single lenses and eyepieces, from 100 to 400, with my 6½-inch With-Browning reflector. With all the star appeared single and its disk *perfectly round.* It was most beautifully defined, more so than I have ever before seen it. Perhaps some of the large telescopes now so common might be tried on this star, which would seem to be now at a critical point in its orbit.

Yours faithfully,

Barrhead, Scotland, 1886, June 30. Edward Bruce Kirk.

On the Proper Motion of Armagh 462 = *Lalande* 6938.

Gentlemen,—

In the 'Monthly Notices' of the Royal Astronomical Society for May 1886, Dr. Dreyer gives the proper motions of 29 telescopic stars. One of these stars, No. 462, has been observed in the zone work of the Cincinnati Observatory. Adding the Cincinnati observation, and correcting a mistake of 10″ in the declination as given in Oeltzen's Argelander (see the original in Bonn Observations, vol. ii.), we have:—

	Epoch of observation.	α 1885·0. h m s	Epoch of observation.	δ 1885. ° ′ ″
Lalande ..	1799·88	3 38 42·13	1799·88	−19 28 63·0
O. Arg. ...	1850·92	43·02	1850·92	53·5
Armagh ..	1871·96	43·60	1865·95	53·0
Cincinnati	1885·96	43·69	1885·96	46·0

Hence result the approximate proper motions $+0^{\mathrm{s}}{\cdot}019$ and $+0''{\cdot}19$.

---

[*] Smyth's 'Celestial Cycle,' Art. 177.

[†] Gore's 'Catalogue of Known Variable Stars,' p. 172.

Applying these we get:—

	h	m	s	°	′	″
Lalande	3	38	43·75	−19	28	46·8
O. Arg.			43·67			47·0
Armagh			43·85			49·4
Cincinnati			43·67			46·2

The Cincinnati positions given above are not final, as the star is to be re-observed before the publication of our catalogue.

Cincinnati Observatory,
1886, June 24.

J. G. PORTER.

Proper Motion in a faint Star.

GENTLEMEN,—

A probable case of strong proper motion in a faint star has just been detected in the reduction of the zone work of this observatory.

The positions, as far as I have been able to collect them, are as follows:—

		Epoch of	α 1885·0.			δ 1885·0.		
	Mag.	observation.	h	m	s	°	′	″
Lamont..........	9·5	1847·69	21	13	45·49	—20	18	25·1
Wash. Mer.-cir. z. .	9	1848·67			46·36			26·6
Wash. Trans.-cir. z.	9	1848·67			45·33			26·9
O. Arg...........	9	1849·79			45·60			25·1
Bonn VI.	9	1851·78			45·60			26·1
Cincinnati	9	1885·75			45·26			51·8

A proper motion in declination of about —0″·7 is here indicated, but the evidence therefore depends entirely on the Cincinnati observations.

The star has been observed here three times, and the results agree fairly. I would be very glad, however, if it might be observed elsewhere. J. G. PORTER.

Cincinnati Observotary,
1886, June 24.

Universal Time.

GENTLEMEN,—

I am sorry to see that Greenwich Observatory is already adopting civil time in its publications referring to some branches of astronomy, and I hope they have not fixed yet to introduce it into all branches in 1891, for I quite agree with Prof. Weiss that the proposed change as to the beginning of the day should not be made till it can be done simultaneously throughout the whole astronomical world. If one nation commences before others, then it will be the duty of astronomers in that nation to add the words "new time" or "civil time" to all their observations until the plan is adopted by general consent. As yet we seem so far from unanimity, that the best suggestion seems to be to continue the old time to the end of the century, and endeavour to obtain uniformity in commencing the new time with New Year's day, 1901. The difficulty in this case would be that the general public will probably be ready for the change sooner, because the present plan is so inconvenient, especially in railway-guides &c., and becomes increasingly so as routes increase in length.

I do not see the inconvenience to meteorologists imagined by Prof. Weiss, p. 265; for surely it is not proposed that local time should never be referred to. It is very easy in the example he gives to say, "the temperature daily maximum occurs shortly after 14^h local time," if the words he uses in explanation are not themselves sufficient. Meteorologists are inconvenienced as much as any one by the present system. Take, for example, the Daily Weather Reports issued by the Meteorological Office; they contain no statements anywhere as to what time is used for the morning and afternoon observations, though there is such a statement for the evening ones—not very complete, however, inasmuch as it does not mention the nature of the time used in Germany, Holland, and Belgium. With reference to the morning observations, I find that though they are said to be at 8 A.M., they are not simultaneous, nor is there any fixed principle as to the time adopted.

Surely astronomers in all countries will come to see the desirability of having a uniform principle in the reckoning of time, both for astronomical and for all other purposes and in all places. Many who write on the subject seem to forget that astronomers are not only astronomers, but that they have civil duties as well, and many also are meteorologists; and to have two different kinds of time would be very confusing when both are reckoned from 0^h to 24^h. At present the confusion is not felt, because when civil time is used the letters A.M. or P.M. must always be added, whereas in astronomical time they are omitted; but when these letters are abolished this distinction will cease, and it will be impossible then to know which time is used without a distinct statement. It must be remembered that there are many subjects which are on the border-land of astronomy and meteorology; and if different modes of reckoning are used for the two sciences, it will be impossible to tell in these cases which of the two is employed unless it is specially stated. T. W. Backhouse.

Sunderland, 1886, *July* 16.

NOTES.

Total Solar Eclipse of 1886, Aug. 29.—The British Expedition for observing the total eclipse of the Sun on August 29 will start from Southampton on Thursday, July 29, by S.S. 'Nile,' *en route* for Barbadoes, whence they will be conveyed to Grenada by a Government vessel, H.M.S. 'Comus.' The whole voyage is expected to occupy 14 or 15 days. This will give a fortnight for fixing and adjusting instruments and for preliminary work. The duration of the total phase at Grenada, one of the Windward Isles, is 3^{m} 52^{s}. The duration will be longest (6^{m} 35^{s}) at a point in the Atlantic (long. 17° W., lat. 4° N.).

At Benguela, where the total phase lasts about 4¾ minutes, the climate and weather are too unfavourable for an expedition.

There are conflicting reports respecting the weather at Grenada, some giving very little promise of fine weather for this period of the year. Let us hope these prognostications may prove incorrect. The general climate of Grenada is healthy and much preferable to Benguela. In size it is not quite so large as the Isle of Wight, being about 20 miles long and 13 broad.

The *personnel* of the Expedition gives promise of good work, for we have Messrs. Darwin, Lockyer, Maunder, Perry, Schuster, Thorpe, and Turner. Perhaps the clearest conception of the work to be done may be formed by taking each observer's programme separately.

Mr. Lockyer takes two equatoreals which are adapted to take 3-inch and ¾-inch pictures of the corona. The photographic plates are to have various exposures, some instantaneous.

Dr. Schuster intends taking photographs of the corona and also of its spectrum. For the latter purpose he will take two sections through the corona, employing a spectroscope with a resolving power of about six in the yellow. (The unit of resolving power being that resolving power which allows the separation of two lines differing by the thousandth part of their own wavelength.)

Mr. Maunder takes a 4½-inch photographic lens, of about 5 ft. focus, for obtaining photographs of the corona in the primary focus; as many as possible to be taken. He also takes a spectroscope with camera, the slit being placed tangentially to the Sun's limb, and one exposure during the whole of totality. This spectroscope has two flint prisms of 62°. At the same time he will use a spectroscope, slit diametrical, with camera, the exposure to be during the whole of totality. It has one large prism of 60°.

The Rev. S. J. Perry takes a 5½-inch and a 4-inch, both equatoreally mounted, but no clockwork; a direct-vision spectroscope on its own stand, and made also adaptable to the 5½-inch; a grating also adapted to the 5½-inch; a direct-vision spectroscope adapted to the 4 inch; and a solar prism also adapted to the latter. The work he proposes to do embraces the observation of first and last contact with the solar prism on the 4-inch; the determination of the exact position of all the bright lines from W.L. 560 to b, at 8^{m}, 6^{m}, 4^{m}, and 2^{m} before totality, and duplicated after totality; searching for the carbon bands near b_4 and W.L. 558, and also for any difference of spectrum in the inner corona near the poles and near the equator of the Sun; and other spectroscopic observations.

Mr. Turner has a 6-inch equatoreal by Simms, with clockwork; a grating spectroscope adapted to it—the grating (1¾ inches) being lent by Capt. Abney. Mr. Turner proposes to observe the order of appearance before totality—or disappearance after—and relative lengths of six bright lines of iron near F. During totality, with a 4-inch telescope on the same equatoreal mounting, he intends looking for currents in the inner corona.

Capt. Darwin takes a coronagraph, an instrument invented by Dr. Huggins for taking photographs of the corona in ordinary sunlight. No lenses are used, the image being produced by a concave mirror, and thus reducing the amount of scattered light to a minimum. A comparison of photographs taken before and during the eclipse will show whether the corona obtained is the true corona, or is due to some atmospheric or instrumental cause. Another test, and possibly a more important one, is to see whether, when the Sun is partially eclipsed, the image of the Moon can be seen eclipsing the corona. During the eclipse a prismatic camera will be attached to the instrument in order to take photographs in a similar manner to that adopted in the two last eclipses.

Prof. Thorpe, who replaces Capt. Abney, will observe the intensity of the light of the corona.

THE CAPE OBSERVATIONS OF THE GREAT COMET 1882 II.—These observations have been published in separate form, and occupy Vol. ii. part 1 of the 'Annals of the Royal Observatory, Cape of Good Hope.' It will be remembered that this comet was first seen by Mr. Finlay on Sept. 7th, 1882, and is remarkable from the circumstance that both Finlay and Elkin watched it close up to the Sun's limb. It has since been found that the comet did not disappear behind the Sun, but was projected on its disk. Dr. Gill gives the whole history of this phenomenon very clearly. Then follow descriptions of the nucleus and tail, accompanied by numerous drawings, sketches, and six very fine photographs taken by Dr. Gill, with the assistance of a local photographer, Mr. Allis. The observations for position were made with the transit circle, the Indian theodolite, a 6-inch equatoreal, a 7-inch equatoreal, and the heliometer. These are all given in separate tables, and finally the apparent places of the comet arranged in order of date, and altogether forming a very valuable series.

THREE LETTERS BY KEPLER [*].—When editing the Works and Correspondence of Kepler ('Kepleri Opera Omnia'), Dr. Frisch expressed the opinion that Kepler must have written three letters to the Bavarian Chancellor, Herwart von Hohenburg, in March, May, and July, 1599, which, being unable to find after a diligent search, he concluded had perished. Herr Anschütz, however, whilst engaged in studying the Latin Codices of 1607 at the Munich State Library, was fortunate enough to discover three long letters of Kepler, which proved to be those which Dr. Frisch had failed to find, thus fully confirming his conjecture that such had been written. They are here printed and published for the first time amongst the sessional Reports of the Bohemian Society of Sciences, and fill up the gap in the correspondence of Kepler, which may now be considered complete. The three letters in question are much more comprehensive than Dr. Frisch supposed, and are indeed some of the longest of Kepler's which are in existence. Amongst other points treated of are the writer's views on chronology, on magnetism, and on astrology. In the astronomical portions it is noteworthy that Kepler, whilst expressing great admiration of Tycho Brahe in general, points out in several places the small probability of the truth of his theory of the solar system, and avows himself a warm supporter of that of Copernicus.

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[*] Ungedruckte Wissenschaftliche Correspondenz zwischen Johann Kepler und Herwart von Hohenburg, 1599. Edited by C. Anschütz.

KAM'S STAR CATALOGUE*.—A star catalogue has been compiled by Dr. N. M. Kam from the places of stars determined by independent meridian observations, which have been extracted from vols. 1–66 of the 'Astronomische Nachrichten,' and reduced to the epoch 1855·0. The work was commenced many years ago by Hoek, then director of the Utrecht Observatory, in accordance with the desire of Argelander, in order that the positions of the great numbers of stars which are determined in connection with observations of planets and comets should be collected and formed into a catalogue. Dr. Kam, who was Hoek's assistant, took up the work on the death of the latter, and has at length been able to finish and publish it. The principal star catalogue, containing 4890 star-places which refer to 4350 different stars whose places are completely determined, is followed by two subsidiary catalogues—the first of which gives 240 star-places referring to 236 stars, and the second 335 star-places; all of these latter, however, are incomplete, *i. e.* the place is given in one element only. These catalogues are followed by a comparison of the places of the stars contained in them, with their places as given in the D.M. or, for stars south of −2° Dec., with other authorities. Copious notes on errata, proper motions, &c. are appended by Dr. Kam and are of great interest and value. It may be pointed out that no attempt has been made to reduce the star-places in these catalogues to a uniform system. The name of the observer and the place of observation is, however, given in each case, and Dr. Kam is able to inform us generally as to the usual plan of reducing star-places which was in vogue at the principal observatories at the dates with which he is concerned, so that it will be possible to use his results for determining the proper motions of individual stars with some degree of confidence.

* Verhandelingen der Koninklijke Akademie van Wetenschappen, Deel xxiv. (Amsterdam, 1886).

SCHULHOF'S RESEARCHES ON THE ORBIT OF THE COMET 1873 VII. (COGGIA-WINNECKE) *.—This paper is mainly an examination of the orbits and positions at various epochs of the Comets 1873 VII. and 1818 I., the identity of which has been asserted by Prof. Weiss, who found that the elements of these two bodies bore some resemblance to each other, and that a periodic time of 6·2 years satisfied the observations fairly well. M. Schulhof has discussed the problem in a most exhaustive manner, and has included in his investigations the question as to whether the Comet 1457 I., the observations of which by Toscanelli have been recently discussed by Prof. Celoria in 'Astronomische Nachrichten,' No. 2627, may not also be identical with 1873 VII. The conclusions at which M. Schulhof has arrived are the following (which he puts forward with some reserve). The Comets 1873 VII. and 1818 I. are distinct bodies, each with a short period of revolution and having a common origin. The Comet 1457 I. is probably identical with 1873 VII., but it is also possible that the two Comets 1873 VII. and 1818 I. may be fragments of 1457 I., which must have been larger and brighter than either of them, as it was seen with the naked eye by Toscanelli and by the Chinese at a time when its theoretical intensity was not greater than that of 1873 VII.

THE STRASSBURG OBSERVATORY †.—Previous to his departure for Göttingen, where he has been appointed Director as successor to the late Prof. Klinkerfues, Herr Schur has published a Report, dated May 1886, supplementary to his last annual report bearing date July 1885 ('Observatory,' Vol. viii. p. 344), thus bringing up his account of the proceedings at the Observatory to the time of his leaving Strassburg. The observations made during the interval to which the report refers were chiefly those of the Moon with the altazimuth, Comets with the great refractor, the southern stars in the extension of the 'Durchmusterung,' as well as Auwers' 83 southern fundamental stars and refraction stars, with the meridian circle. The direct and reflection observations made with the latter instrument up to the end of last year give for the geographical latitude of the meridian circle $+48^\circ\ 35'\ 0''\cdot 11$, which agrees well with a former determination with Repsold's transit, using Harrebow's [Talcott's] method, viz. $+48^\circ\ 35'\ 0''\cdot 23$. Herr Schur has on previous occasions drawn attention to the discordance between the Nadir points determined with Observer North and Observer South, which for his own observations is a considerable quantity, the results up to the middle of February of this year giving for $\frac{1}{2}$(North—South) as much as $+0''\cdot 50$. This agrees in magnitude as well as in sign with the quantity deduced from observations of zenith-stars for corresponding positions of the observer, viz. $0''\cdot 77$,

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* Bulletin Astronomique, tome iii. p. 125 *et seq.*

† Astron. Nachr. No. 2736.

and Herr Schur concludes that his observations of zenith distances of stars require a correction of about −0″·6. For the other Strassburg observers this correction appears to be relatively insignificant. Herr Schur is succeeded at Strassburg by Dr. Kobold.

BLACK TRANSIT OF JUPITER'S FOURTH SATELLITE[*].—Mr. E. E. Barnard, of Nashville, Tenn., U.S.A., observed the fourth satellite of Jupiter in black transit on May 8. The satellite was first noticed as a black spot at $9^h\ 20^m$ local mean time. Some little time previous to this it had been looked for on the disk, but could not be seen either as a white or dark spot. At $9^h\ 43^m$ the satellite still appeared very black and rather small and round when best seen. The satellite was not followed after this observation. Mr. Barnard was observing with a 6-inch refractor.

OBSERVATIONS OF THE COMPANION OF SIRIUS[†].—The following are the mean results of the measures of the companion of Sirius made at Princeton, N.J., during the last three years. For the most part the observations were made by Prof. Young, and with the 23-inch refractor with powers 460 and 300.

Position-angle.			Distance.		
Epoch.	Measure.	No. of Nights.	Epoch.	Measure.	No. of Nights.
1883·105	39°·00	1	1883·105	9″·41	1
1884·273	36 ·30	5	1884·270	8 ·70	4
1885·112	34 ·06	7	1885·089	8 ·09	8
1886·047	29 ·77	4	1886·049	7 ·59	3

It is remarked that during the present year the companion has been quite a difficult object, except when the seeing was good, and that there have been fewer good nights than usual.

METHOD OF CORRECTING FOR DIFFERENTIAL REFRACTION IN DECLINATION[‡].—Mr. Malcolm McNeill, Assistant Professor of Practical Astronomy in the College of New Jersey, has devised a method of correcting micrometer observations for refraction applicable to the diagonal-square micrometer, to the ring micrometer, and all others of that class in which a difference of declination is determined by transits of the stars over wires inclined to the hour circle. The speciality of the method consists in this, that the correction to the difference of declination is not determined separately, but the true difference is directly determined, the corrections being applied to the logarithms in the course of the computation. Mr. McNeill shows that if we apply the number given by $-M\kappa(\tan^2\zeta \sin^2 q + 1)$ to the logarithm of the half chord traversed by the star, and the corresponding number given by $M\kappa(\tan^2\zeta \cos^2 q + 1)$ to the apparent distance from the point of reference in the micrometer (measured on a circle of declination), the result obtained will be the true difference corrected for refraction. In the above expressions M is the modulus of the common system of logarithms, κ the constant of differential refraction, ζ the true zenith distance, and q the parallactic angle. It is only then necessary to tabulate the expression $M\kappa\{\tan^2\zeta \cos^2(p-q)+1\}$, with arguments $p-q$ and ζ, to obtain the quantities necessary (by making p alternately $=90°$ and $=0°$) to correct the micrometer measures for differential refraction. This Mr. McNeill has done, and his tables will doubtless prove most acceptable to observers using the class of micrometer to which the method is applicable.

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[*] The Sidereal Messenger, No. 46, p. 184.

[†] Ibid. p. 182.

[‡] Astron. Nachr. No. 2735.

THE LICK EQUATOREAL.—From the 'Sidereal Messenger' we learn that the contract for mounting the 36-inch objective has been awarded by the Lick Trustees to Warner and Swasey of Cleveland, Ohio, for $42,000. The telescope is to be 57 feet long, and the diameter of the tube 42 inches. The tube is suspended at the middle and the point of suspension is to be 37 feet above the floor of the dome. The axes on which the tube move are supported by a heavy iron column, 17 feet by 10 feet at its base. Provisions are made by which it is possible for the observer at the eye-end of the telescope to command all the possible motions, and these same motions can also be controlled by an observer stationed on a small balcony 20 feet above the floor, and it is expected that little physical force will be required. The mounting is to be completed in April 1887, and the glass mounted some time during the summer of 1887. The cost of the entire apparatus is as follows:—Cost of dome, $56,850; cost of mounting, $42,000; cost of the visual objective, $53,000; cost of photographic objective, $13,000; total, $164,850. Besides these sums several thousand dollars will be required to put the instrument into its final completed state.

MICROMETRICAL MEASURES OF GASEOUS SPECTRA UNDER HIGH DISPERSION*.—A very striking and valuable paper under the above title, read by Prof. Piazzi Smyth before the Royal Society of Edinburgh on June 16, 1884, has recently been published in separate form. It contains a very detailed examination of the spectra of hydrocarbon in the blowpipe-flame and in the vacuum-tube, and of carbonic oxide, hydrogen, oxygen, and nitrogen in vacuum-tubes. These spectra were originally designed on a scale which gave 120 feet from the red to the violet, but are here represented on a scale but one third as great. The plates, 29 in number, are graphical representations of the spectra, the brightness of a line being represented by its length; an accompanying scale gives the wave-number per British inch. A thirtieth plate, which is coloured in six colours, gives a chart of the different spectra on a reduced scale and acts as an index map. The thirty-first plate illustrates the most interesting and remarkable result of Prof. Smyth's measures. Having devoted special attention to that portion of the great green band of the CO spectrum, which projects beyond the edge of the great green band of the CH spectrum towards the red (viz. from λ 5164 to λ 5196), Prof. Smyth sent the record of the places of the 44 lines which he had observed in that district to Prof. Alex. S. Herschel, and the latter almost immediately discovered that this apparently irregular group of lines really consisted of two very simple and closely related series—one a series of single strong lines, the distances between the successive lines increasing in arithmetical progression, the other a series of close double lines also in arithmetical progression, the two series being so related that if the latter series were shifted until its first member took the place held by its fifth, the two series would correspond exactly within the limits of observation member by member from beginning to end.

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* "Micrometrical Measures of Gaseous Spectra under High Dispersion." By C. Piazzi Smyth, F.R.S.E., and Astronomer Royal for Scotland. From the 'Transactions of the Royal Society of Edinburgh,' Vol. xxxii. part iii. Edinburgh: Neill & Co.

This is decidedly the most striking outcome of the measures here given; but Prof. Smyth's remarks on the other spectra observed are full of interest and value—notably Part V. on the three spectra of oxygen, and Part III. on the differences between the CH and CO spectra. There is a very natural and pardonable exultation manifest at the complete success which has attended his view as to the true nature of the well-known spectrum of the Bunsen flame. And apart from the importance of his subject, it is always enjoyable to read what Prof. Smyth has to say; his easy and romantic style lends a charm to every subject that he handles.

MINOR PLANET 253 has received the name of Mathilde; Minor Planet 254 has received the name of Augusta. A new Minor Planet, No. 259, was discovered by C. H. Peters, of Clinton, on June 28.

DR. SCHWARZ, Assistant at the Prague Observatory, is desirous of obtaining unpublished observations of Comet 1880 II. (Schäberle).

CORRECTION.—In our issue, No. 110 (May), p. 196, "or with 60° east elongation 178°," should be "or with 60° east elongation, 178° geocentric longitude."

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HE OBSERVATORY,

MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

:—

PAGE
rsonal Errors in Double-Star Observations. By H. C. WILSON 297
r Notes. By W. F. DENNING, F.R.A.S. 301
ariable Star L² Puppis. By A. STANLEY WILLIAMS, F.R.A.S. 302

pondence :—

ni. By Dr. COPELAND, F.R.A.S., Dr. F. TERBY, F.R.A.S., H. SADLER, .R.A.S., Rev. JEVON J. MUSCHAMP PERRY, F.R.A.S., and KENNETH J. ARBANT 304–308
anion Comets.—II. By W. H. S. MONCK, M.A., F.R.A.S. 309
a and Spectrum. By the Rev. EDWARD BRUCE KIRK 311
rsal Time. By Capt. WILLIAM NOBLE, F.R.A.S. 312
Aurora. By the Rev. S. J. JOHNSON, F.R.A.S. 312
and the Constellations. By W. T. LYNN, B.A., F.R.A.S. 313
rmer Variability of 34 Cygni. By W. T. LYNN, B.A., F.R.A.S. 314

—

Rainband.—The Visual Solar Spectrum in 1884.—Astronomical hotography.—The Observatory of Yale College.—Variable Stars.—bituary: Rev. S. H. Saxby, M.A., F.R.A.S.—The Longitude of the leGill College Observatory.—The Hongkong Observatory.—The Prorse of Astronomy in the Year 1885.—The Total Solar Eclipse of ugust 29.—Editorial Notes 315–320

Elements of Comet 1886 (Brooks 3). By Dr. S. OPPENHEIM 320

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and T. Lewis, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpool Astronomical Societies; Articles by various eminent Astronomers, English, American, and Continental; Correspondence on topics of interest connected with the Science; Notes on the progress of Astronomy; Reviews of astronomical publications; Ephemerides of comets, variable stars, Saturn's satellites, and for physical observations of the Sun, Jupiter, &c.; and all the usual astronomical information.

Amongst the contributors to 'The Observatory' in 1885 were Professors Asaph Hall, Holden, Hough, Pickering, Pritchard, and Young; Dr. Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs. Barnard, Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"—*Bulletin Astronomique* (organ of the Paris Observatory).

CONTENTS OF No. 113.

PAGE

Meeting of the Liverpool Astronomical Society 273

Articles:—

Large *v.* Small Telescopes. By W. F. Denning, F.R.A.S. 274
Brooks' Second Comet, 1886. By E. E. Barnard 278
Meteor Notes. By W. F. Denning, F.R.A.S. 279

Correspondence:—

Companion Comets. By W. H. S. Monck, M.A., F.R.A.S. 279
Periodic Comets. By W. C. Evans, M.A., F.R.A.S. 282
The Comet of 1366. By W. T. Lynn, B.A., F.R.A.S. 282
Halley's Comet at its Appearance in 1759. By W. T. Lynn, B.A., F.R.A.S. 284
Algol's Hypothetical Satellite. By J. R. Sutton, F.R.A.S. 286
δ Cygni. By the Rev. Edward Bruce Kirk 287
On the Proper Motion of Armagh 462=Lalande 6938. By J. G. Porter ... 287
Proper Motion in a faint Star. By J. G. Porter 288
Universal Time. By T. W. Backhouse, F.R.A.S. 288

Notes:—

Total Solar Eclipse of 1886, August 29.—The Cape Observations of the Great Comet 1882 II.—Three Letters by Kepler.—Kam's Star Catalogue.—Schulhof's Researches on the Orbit of the Comet 1873 VII. (Coggia-Winnecke).—The Strassburg Observatory.—Black Transit of Jupiter's Fourth Satellite.—Observations of the Companion of Sirius.—Method of Correcting for Differential Refraction in Declination.—The Lick Equatoreal.—Micrometrical Measures of Gaseous Spectra under High Dispersion.—Editorial Notes 289-29

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 114. SEPTEMBER. 1886.

On Personal Errors in Double-Star Observations *.

It may be of interest to give here the results of an investigation of my personal errors during the period from 1882 to 1886. For this investigation I selected those stars which I had observed with both positions of the eyes (*i. e.* with the line joining the centres of the eyes both normal and parallel to the line joining the stars) on the same night, in order to eliminate the effects of bias peculiar to certain nights. Most of the observations were made with a magnifying-power of 450. In the preliminary investigation I used only the measures made with that power. Afterwards measures made with other powers were included, the differences having been first multiplied by the square root of the ratio of the magnifying-power to 450. The difference *normal – parallel* for each pair of measures of position-angle then gave an equation of the form $e=a+bw$, in which w represents the reciprocal of the distance between the stars, and a and b are coefficients to be determined, and which depend upon the angle with the vertical, the method of observing, and the peculiarities of the observer.

Dividing the equations into groups depending upon the angle with the vertical, and solving by the method of least squares, the following set of equations was obtained:—

V.	*n–p.*	No.	V.	*n–p.*	No.
0° ..	......	..	90° ..	......	..
25 ..	$e=-0^{\circ}{\cdot}7-3^{\circ}{\cdot}4\,w$	35	115 ..	$e=+0^{\circ}{\cdot}3+4^{\circ}{\cdot}2\,w$	35
45 ..	$=-0\ {\cdot}4-4\ {\cdot}5\,w$	36	135 ..	$=+0\ {\cdot}0+4\ {\cdot}7\,w$	33
65 ..	$=-0\ {\cdot}3-3\ {\cdot}3\,w$	26	155 ..	$=+1\ {\cdot}0+2\ {\cdot}1\,w$	23

The groups near 0° and 90° were omitted, because I had neglected to note the directions in which my head had been turned for each measure. The signs in those groups were therefore discordant, and I did not feel at liberty to change them arbitrarily to make them agree. It will be seen that the signs are all negative in the first quadrant and positive in the second, and that the coefficients do not differ more than can be accounted for by accidental errors of observation. Indeed, if we take the mean of the three equations in each quadrant, we shall find that they are numerically identical. It is probable that the difference $n-p$ is constant for any given distance, and the corrections n and p will therefore be complementary to each other. I preferred, however, to retain the coefficients as they stand in the above equations, and to form from them, by interpolation, a table of corrections, assuming that the error should be equally divided at 45°, and that it should belong wholly to the parallel measures at 0° and to the normal measures at 90°. After the preliminary corrections had been applied, the arithmetical means of all the observations of each star were taken, and from these means the individual uncorrected observations were subtracted. The resulting differences, arranged in groups according to angle and distance, are given in the following tables :—

---

* From the 'Sidereal Messenger' for July 1886.

Distance.	15°.		No.	45°.		No.	75°.		No.
	n.	*p.*		*n.*	*p.*		*n.*	*p.*	
″ ″	°	°		°	°		°	°	
0– 2	+0·3	−3·8	8	+1·2	−2·2	18	+4·3	−0·7	4
2– 8	+0·2	−1·6	16	+0·9	−0·9	20	+1·4	−0·4	15
8–32	+0·2	−0·8	12	+0·5	−0·5	13	+0·9	−0·1	6
	105°.			135°.			165°.		
0– 2	−4·2	+0·8	10	−2·0	+1·6	15	−0·4	+3·6	11
2– 8	−1·4	+0·4	15	−0·6	+0·3	25	−0·4	+1·6	16
8–32	−0·6	+0·2	5	−0·3	+0·2	16	−0·2	+0·7	6

The corrections seem to be practically the same in both quadrants, only in reverse order; also, the corrections to normal are the same as those to parallel in the reverse order. They may therefore be combined, without regard to sign, in groups which depend upon the angle of inclination of the head; and if the mean distances of the three groups be assumed 1″, 5″, and 16″, we shall have

Distance.	15°.	45°.	75°.
1″	±0°·5	±1°·7	±4°·0
5	±0 ·3	±0 ·7	±1 ·5
16	±0 ·2	±0 ·4	±0 ·8

The sign + applies when the head is turned to the left, and sign − when the head is turned to the right. In these groups the corrections are approximately proportional, directly to the angle, and inversely to the square root of the distance. They may therefore be represented with a sufficient degree of accuracy by the general formula $c=a\mathrm{I}\sqrt{w}$, in which I represents the angle of inclination of the head, and a is the only coefficient to be determined. Applying this formula to all of the observed differences, I obtained the following values of a for the three groups :—

15°	....	$a=+0·040$
45	....	$a=+0·038$
75	....	$a=+0·043$
Mean	....	$a=+0·040$

The agreement between these values is quite satisfactory, and a may be assumed constant.

The above corrections may be perhaps a little more accurately represented by the formula $c=a+bw$, but the coefficients a and b will vary with the angle. The equations for the three groups will be

$$15^\circ \quad \ldots\ldots \quad c=+0^\circ{\cdot}2+0^\circ{\cdot}4\,w$$
$$45 \quad \ldots\ldots \quad c=+0\;{\cdot}3+1\;{\cdot}5\,w$$
$$75 \quad \ldots\ldots \quad c=+0\;{\cdot}6+3\;{\cdot}4\,w$$

The corrections computed by the two formulæ are nearly identical up to 75°, and observations made with the head inclined more than 75° should be rejected. I prefer therefore to use the first form.

The comparison of the measures of distance gave the following results for normal—parallel:—

Distance.	0°.	No.	45°.	No.	90°.	No.	135°.	No.
″ ″	″		″		″		″	
0- 2 ..	−0·07	7	−0·03	13	+0·08	2	−0·01	13
2- 8	−0·05	12	0·00	21	+0·10	14	−0·03	26
8-32	−0·15	5	+0·01	12	+0·06	2	+0·03	7
Mean	−0·09	24	0·00	46	+0·09	18	0·00	46

The fact that the parallel measures are the greater at 0° and that the normal measures are the greater by the same amount at 90°, *i.e.* the measures in which the head is inclined most are largest, would seem to indicate that the inclination of the head produces a tendency to exaggerate distances; while the fact that the measures are equal at 45° and 135°, where the inclination is equal in either direction, would seem to show that no effect is produced upon the distances by the different relative positions of the eyes and stars. It is probable that the measures would be improved by the application of a system of corrections something like the following:—

	n.	*p.*
0°	0″·00	−0″·09
45	−0 ·04	−0 ·04
90	−0 ·09	0 ·00
135	−0 ·04	−0 ·04
180	0 ·00	−0 ·09

The effect of neglecting these corrections would, however, only produce a constant error in the distances of about +0″·04. I concluded therefore not to apply any corrections to my observations of distance.

In order to test my personal equation by comparison with other observers, I collected all the available measures of the doubles in my working list, rejecting in the comparison all binaries and doubtful measures. The results of the comparison between my corrected measures and those of W. Struve, Dembowski, Burnham, and the previous Cincinnati observers are given in the following tables, arranged in groups according to angle and distance.

Comparison of Position-angles.

Ang.	W.—Str.	No.	W.—Dem.	No.	W.—Bu.	No.	W.—C.O.	No.
°	°		°		°		°	
0......	−0·1	23	+0·4	20	+0·7	5	+0·6	46
45......	+0·8	10	−0·9	11	−1·3	10	+1·1	44
90......	+0·6	12	−0·5	13	+1·0	9	+0·7	43
135......	+0·7	12	+0·8	16	+1·1	9	+1·3	45
Mean	+0·5		0·0		+0·4		+0·9	

Dist.	W.—Str.	No.	W.—Dem.	No.	W.—Bu.	No.	W.—C.O.	No.
″ ″	°		°		°		°	
1– 2....	+0·6	6	+0·6	12	+0·5	8	+1·8	38
2– 4....	−0·1	17	+0·1	17	−0·4	10	+0·7	42
4– 8....	+1·1	11	−0·4	12	+0·3	6	+0·8	39
8–16....	+0·1	16	0·0	14	−0·1	8	+0·7	38
16–32....	+0·3	7	+0·1	5	....	..	+0·8	21
Mean	+0·4		+0·1		+0·1		+0·9	

Comparison of Distances.

Ang.	W.—Str.	No.	W.—Dem.	No.	W.—Bu.	No.	W.—C.O.	No.
°	″		″		″		″	
0....	+0·11	23	+0·18	20	+0·07	5	+0·05	46
45....	+0·19	10	+0·15	11	+0·21	10	+0·07	44
90....	+0·19	12	+0·25	13	+0·16	9	+0·07	43
135....	+0·16	12	+0·19	16	+0·19	9	+0·03	45
Mean ..	+0·16		+0·19		+0·16		+0·05	

Dist.	W.—Str.	No.	W.—Dem.	No.	W.—Bu.	No.	W.—C.O.	No.
″ ″	″		″		″		″	
1– 2....	+0·02	6	+0·09	12	+0·22	8	+0·08	38
2– 4....	+0·09	17	+0·14	17	+0·07	10	+0·03	42
4– 8....	+0·30	11	+0·33	12	+0·10	8	+0·09	39
8–16....	+0·25	16	+0·30	14	+0·39	6	+0·10	38
16–32....	−0·05	7	−0·02	5	....	..	−0·05	21
Mean	+0·12		+0·17		(+0·19)		+0·05	

Prof. Stone found, by comparison with the corrected measures of W. Struve, that the position-angles in Publication No. 5 of the Cincinnati Observatory require a constant correction of about +0°·6 (Introduction, page xix). This will explain, in part at least, the nearly constant difference between my measures and those of the previous Cincinnati observers as indicated by the column W.—C.O. It appears then, from the first two tables, that my systematic errors in the measurement of position-angles have been satisfactorily eliminated. In the last two tables, on the other hand, all the comparisons conspire to show that my measures of distance, except for large distances, are too great. It is interesting to compare the differences in the last table with the following corrections to the distances of Struve, Dembowski, and Cincinnati observers, as derived by comparison with O. Struve's results (see 'Pulkowa Observations,' vol. ix. page 131, and Publ. Cincinn. Observ. No. 5, page xxiii).

Dist.		Str.	Dem.	C.O.
″		″	″	″
1·6	......	0·00	+0·02	+0·08
2·9	......	+0·14	+0·14	+0·20
5·6	......	+0·22	+0·22	+0·22
12·0	......	+0·19	+0·20	+0·06
23·9	......	+0·08	+0·06	−0·16
Mean	......	+0·13	+0·13	+0·08

When these corrections are applied, my deviations almost entirely disappear. If, then, O. Struve's results are reliable, I may conclude that my measures of distance as well as of angle are nearly free from systematic error.

H. C. Wilson.

Mt. Lookout, Cincinnati,
April 15, 1886.

Meteor Notes.

On August 2, 50 meteors were observed here during a watch of about 4¼ hours; on August 4, 58 were noted during a similar interval. On August 10 bright moonlight prevailed until about $13^h\ 30^m$, and before midnight there were many clouds affording an additional hindrance. I counted 152 meteors up to $14^h\ 30^m$, and of these 122 were Perseids. I judged the display to have been a tolerably rich one, for after moonset the horary number for one observer became about 90. On August 11 the sky was much clouded; but I saw 22 meteors before midnight, of which 15 were Perseids. The radiant-point was at the usual place, and exhibited the same rapid displacement to the E. as observed here in preceding years. (See 'Monthly Notices,' Dec. 1884, pp. 97, 98.)

Of the minor showers of the August period, I determined several of the more decided character. Three of these were very sharply defined, and they had been recognized here during previous observations at this epoch. The positions were

	°	°	
Near θ Cygni..........	291	+51	14 meteors.
λ Andromedæ	350	+51	11 ,,
α–β Persei	48	+43	10 ,,

The meteors of the latter shower belong to the swift, streak-leaving class similarly to the true Perseids. I believe the three radiants specified represent the best streams in simultaneous play with the Perseids during the last few years. They have been detected by several different observers, and are so pronounced that they can hardly elude notice at stations where systematic observations are carried on.

A few brilliant meteors have recently been noted here, and I give the apparent paths as observed :—

				From		To		
1886.	h	m	Mag.	°	°	°	°	
July 31.........	10	53	♃	349	+ 9	346¼	+ 1	Swift, streak.
Aug. 4	10	40	♃	129	+60	83	+40	Very, very slow.
6	10	3	♃	352	+13	320	+ 3	Slow, bright streak.
10	13	34	♀	77	+67	111	+67	Very swift; streak visible 3^m 50ˢ.

The last was a Perseid, and much the finest meteor seen here during the display.

Bristol, 1886, Aug. 17. W. F. Denning.

The Variable Star L^2 Puppis.

The variability of this star was discovered at Cordoba, fourteen or fifteen years ago, but no observations seem to have been made of it elsewhere, which is a matter for regret, as the brightness of the object, the considerable extent of the variation, and the fine deep reddish-orange colour of the star combine to render it a variable of more than usual interest.

In November 1885, I began a series of observations of this star, which soon showed that the time of maximum predicted in the 'Observatory' for November 1885 (viz. 1885, Dec. 9) was somewhat largely in error. The observations were continued, and between Nov. 14, 1885, and March 30, 1886, comparisons of the magnitude were obtained on 33 nights. The magnitudes derived from these comparisons, projected upon a chart, give for the time of maximum, 1886, January 10; more than a month later than the predicted time. The estimations of magnitude were made with an opera-glass, the stars being accurately focussed, and the comparisons being made with some stars in Canis Major, the magnitudes of which were assumed from 'Harvard Photometry.' The following are all the observed times of maxima :—

Observed times of maxima.	Observed Magnitude.	Observer.
1872, March 29 ±	3·6	Davis.
,, August 10 ± ..	3·6	do.
1874, February 8	3·6	Bigelow.
,, June 25	3·5	do.
1866, January 10	3·55*	Williams.

The two maxima in 1872 are only very roughly determined, the first depending upon a single observation, and the other only being estimated from the continuation of a light-curve. In order to find the period of variation, I have therefore relied upon the two maxima in 1874 and the one observed by me in 1886. Forming equations and solving, we get from these data:—

---

* This is the magnitude according to the scale of the 'Harvard Photometry,' which, however, for stars of this magnitude is almost identical with the scale of the 'Uranometria Argentina.' For much brighter or fainter stars considerable corrections have to be applied to the magnitudes of the latter, in order to compare them properly with those of the former catalogue.

Mean Period = 136·05 days.
Epoch = 1878, March 16·0.

Calculating, then, with these elements, the times of maxima, and comparing them with the observed times, including those in 1872, the following residuals are obtained:—

C—O.
+1·20
+3·25
+0·45
−0·50
+0·05

From the Cordoba observations, Gould found a period of about 135 days. The light-curve about the maximum in January 1886 was not regular. The exact period of maximum was fairly well accentuated, and from this point there was a gradual decline of 0·8 mag. in about 48 days, at which period a rather sudden descent of over 0·8 mag. in only six days occurred. The observations at the point corresponding to this sudden drop preceding maximum are not sufficiently numerous to show whether there was a similar irregularity of the light-curve at that part.

Gould remarks that L^2 Puppis is "red in all its stages, and remarkably so when faint." Many observations of the colour of the star were made with the opera-glass, with which it usually appeared "very red" or "deep orange-red" about the time of maximum. The star was too faint at other times in this instrument to distinguish the colour well. From the brightness of the star in the telescope, even near the minimum, it is, however, very well suited for detecting changes of tint, and also for spectroscopic observations, in order to ascertain if the spectrum undergoes any alteration during the changes in brightness of the star. Viewed in the telescope, L^2 is in striking contrast to L^1 Puppis, the colour of which is bluish white.

The following are the calculated times of some of the maxima following that of January 1886:—1886, May 26; 1886, Oct. 9; 1887, Feb. 22; 1887, July 8; 1887, Nov. 22; 1888, April 5; 1888, Aug. 19; 1889, Jan. 2.

West Brighton, July 20, 1886. A. STANLEY WILLIAMS.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

δ Cygni.

Gentlemen,—

In reference to Mr. Kirk's letter, on p. 287, about the invisibility of the companion of δ Cygni with a $6\frac{1}{2}$-inch reflector on June 26, I would point out that it has long been considered highly probable that the small star is variable. It has already been missed by both the Herschels, South, Secchi, O. Struve, and Doberck, at times when it ought to have been visible if of the usual magnitude. Behrmann's second orbit ('Astr. Nachrichten,' No. 1561) continues to represent the actual motion so well* that I take the liberty of extending his ephemeris for a few years.

Ephemeris of δ Cygni.

	App. Position.	Distance.
	° ′	″
1879·0........	327 31	1·458
1880	325 52	1·461
1881	324 13	1·464
1882	322 35	1·468
1883	320 57	1·472
1884	319 20	1·476
1885	317 43	1·481
1886	316 7	1·486
1887	314 32	1·491
1888	312 57	1·497
1889	311 23	1·502
1890	309 50	1·508

The ephemeris gives the least distance, 1″·451, as occurring in 1875, nor is this at variance with the mean results of observation. But it will take many years before the increasing distance can become appreciable, and it will probably then first show itself in a decrease of the angular velocity.

Behrmann's orbit is very interesting, because it now goes far to prove that Sir W. Herschel's position-angle in 1783 was correctly recorded, and that a change of quadrant is inadmissible. Indeed,

---

* When M. Flammarion, in his 'Catalogue des Etoiles doubles et multiples,' wrote (p. 130) that "l'éphéméride donnée par Behrmann de Göttingue ne s'accorde pas du tout avec les observations récentes," he must have inadvertently used Behrmann's earlier computations of the same year, 1865; for the very last observation recorded by M. Flammarion is

1877·14	Pos. 330°·1	Dist. 1″·63	Dembowski,

while Behrmann's ephemeris gives

1877·14	Pos. 330°·6	Dist. 1″·454.

it has been for some time obvious that any great hypothetical increase in the arc described between 1783 and 1826 demands a much larger diminution of the measured distance (2″5) at the earlier epoch than can well be admitted.

For its efficient measurement δ Cygni requires a good telescope and excellent definition—*e. g.* on the 2nd and 6th inst. the companion could be detected, perhaps, once in every four or five minutes, with the 15-inch equatoreal of this observatory. On the 8th, although the air was reasonably clear, the image of the large star, as seen with a high power, was always so diffuse as to embrace and completely absorb the smaller one. The fault was not in the telescope, for, on the 3rd, the definition being, for a time, really splendid, the position and distance were measured with ease :—

	Pos.	Dist.	Hour-angle.	Mags.	Colours.	Power.
1886·59 . .	320°·5	1″·60	$1^h\ 30^m$ W.	4 9	white, blue	820

The distance was about four diameters of the chief star. With power 229 the star was exquisitely double, but did not look nearly so measurable as with the high power. The position-angle seems to be several degrees too large.

Towards the end of the observation, I took particular notice of the way in which the small star was lost to view in moments of bad definition. First of all its image spread out until it became almost indistinguishable from the field illumination. When this stage was reached the rays from the large star spread out over the place of the companion, obliterating every trace of it until good definition returned, when the large star shrunk together, and the small one reappeared. If I have estimated the magnitudes correctly, δ Cygni was about one hundred times as bright as the companion star.

Lord Crawford's Observatory,
Dun Echt, 1866, August 11.

RALPH COPELAND.

MESSIEURS,—

Le no. d'août de 'l'Observatory' que je viens de recevoir me donne l'occasion de vous adresser quelques communications que je serai heureux de vous voir bien accueiller dans votre excellente Revue.

Je lis d'abord, page 287, que M. Kirk n'a pas réussi à voir le compagnon de δ Cygni, le 26 juin, avec son réflecteur de 6 pouces ½ de With-Browning. Vos lecteurs n'ignorent pas que ce compagnon est très difficile à découvrir à cause de son rapprochement de l'étoile principale *joint* à la grande différence d'éclat de ces deux composantes. Pour éprouver l'équatorial de huit pouces (réfracteur) que M. Grubb, de Dublin, a construit pour moi, j'ai fait quelques essais de δ Cygni, à la même époque, et voici les résultats :

Le 25 juin, je ne réussis pas à voir le compagnon ; le crépuscule est déjà trop avancé.

Le 27 juin, je vois le compagnon, immédiatement après le coucher du soleil, avec un grossissement de 650 fois environ.

Le 30 juin, le compagnon reste douteux ; j'observe plus tard que le 27 ; les anneaux d'interférence masquent trop la petite étoile.

Le 1 juillet, au coucher du soleil, je vois admirablement bien le compagnon.

Je saisis cette occasion de rendre un hommage public au constructeur habile et consciencieux de mon équatorial ; les épreuves dont je parle ont conduit à la conclusion que cet objectif possède une puissance optique remarquable à tous les points de vue et donne tout ce qu'un objectif de sa dimension est capable de donner. Je me permets de citer ici quelques résultats :

Pouvoir séparateur.—Mon huit pouces dédouble parfaitement (en 1886) :

ζ Cancri AB, OΣ 175, μ^2 Boötis, η Coronæ, ζ Herculis, ζ Boötis, ω Leonis, 25 Canum, 35 Comæ, Σ 1863, Σ 1883, Σ 1876, Σ 1932, OΣ 219, Σ 1426 A B et C, Σ 1429, Σ 1439, Σ 1517, δ Cygni, λ Cygni, ξ Scorpionis AB, γ Scorpionis AB et CD, π Aquilæ, Σ 1999, OΣ 237, OΣ 235, Σ 1781, Σ 1846, Σ 2428, OΣ 384, OΣ 386, Σ 2606, Σ 2607, OΣ 395, OΣ 418, Σ 2437, Σ 2696, ε Equulei A B et C, Antarès.

Pouvoir lumineux.—Quoique la liste précédente contienne déjà des résultats concluants à l'égard du pouvoir lumineux, je citerai encore les résultats suivants : Je vois les sept petites étoiles de Dawes entre ϵ^1 et ϵ^2 Lyræ, le compagnon de α Serpentis, celui de τ Boötis, C de OΣ 249, le compagnon de Σ 2590, celui de β Aquilæ, les deux compagnons de 5 Aquilæ, celui de 23 Aquilæ, et les trois compagnons de β Equulei.

Comme annexe à ce qui concerne le pouvoir séparateur, et comme preuve de la *perfection des images*, je dirai que, jusqu'ici, j'ai constaté parfaitement la duplicité des étoiles suivantes, par l'allongement ou la forme de leurs images : Σ 2106, χ Aquilæ, Σ 2173, Σ 2107, Σ 1834, Σ 1879, Σ 2996, OΣ 249 AB.

Pouvoir définissant.—Les taches de Mars se reconnaissaient encore très bien le 5 juin ; on voyait parfaitement encore une tache blanche, brillante au pôle boréal. Le 9 juillet, le petit cratère dans la tache blanche lunaire Linné était très évident. Ces essais sont encore à poursuivre.

Dans le même no. de 'l'Observatory,' p. 275, M. Denning s'étonne au sujet d'une allusion faite par le Professeur Young, de Princeton, à des dessins de Mars exécutés à l'aide du grand équatorial de Washington, par M. Holden, et qui m'ont été communiqués. Ces dessins datent de 1875 et avaient été envoyés préalablement à la R. A. S. qui en a fait mention dans les 'Monthly Notices,' xxxvi. 1876, p. 13. Malheureusement, comme tant d'autres, ces dessins n'avaient pas été publiés, fait regrettable au point de vue des progrès de l'aréographie. Ces dessins ne contiennent pas tous les canaux de M. Schiaparelli, mais j'ai montré qu'ils renfermaient

incontestablement les canaux : Hiddekel, Triton, Nepenthes, Xanthus, Scamander, Cyclopum, Læstrygonum, le Nilus et le Fluvius.

J'aurais désiré vivement faire une étude soignée de Mars cette année à l'aide de mon équatorial de Grubb, dont il est question dans cette lettre ; mais son installation n'a été achevée complétement que longtemps après l'opposition.

Je vous prie, Messieurs, de bien vouloir me croire

Votre bien dévoué,

Louvain, le 30 juillet 1886. DR. F. TERBY.

GENTLEMEN,—

Mr. Kirk's failure to see the companion of this star must be due either to personal, instrumental, or atmospheric causes. The distance of the *comes* has undergone but little if any alteration since it was measured by Struve in 1826, and probably none has really occurred since it was discovered by Sir W. Herschel on September 20, 1783. He found the angle to be 18° 21′ *nf*, *i. e.* 71°·65 in the usual mode of reckoning, and estimated the distance of the smaller one at from $1\frac{1}{3}$ to $1\frac{1}{2}$ diameters of the larger, with a power of 932 on his 7 feet reflector of $6\frac{1}{3}$ in. aperture. I may remark that the MS. diagram lends no support to Dunér's suggestion ('Mésures Micrométriques,' p. 235) that for *nf* we should read *sf*. It had been supposed that the companion was never seen after 1783 by Sir William; but I have given an observation of his from the MSS. in my "Notes and Corrections to Sir J. Herschel's Synopsis," in the 'Monthly Notices' for March 1885, which shows that he saw the star clearly divided in 1803. Dawes remarks (Mem. R. A. S. xxxv. p. 416):—"It is difficult to account for its non-visibility in the powerful reflectors of ♅ in 1802 and 1804; since it was first discovered and readily seen with a much smaller instrument in 1783; especially as at that time it was almost as far from the larger star. But this is especially an object in which great perfection in the telescope is of far more importance than large aperture, beyond about 6 inches." I give below copies from Sir W. Herschel's MSS. of his observations of this object after 1783; it will be observed that in 1803, when the star was clearly divided, Herschel used his very perfect $6\frac{1}{3}$-in. reflector of 7 feet focus, probably with a power of 460.

"January 3rd, 1802.—I cannot see the small star of δ, neither with 400 nor 600, but there is a strong vibration in the objects owing to frost. This star I suppose requires the finest night possible." (12-inch reflector.)

"January 11th, 1802.—I looked last night for nearly half an hour at δ Cygni, but could not perceive the small star. It may possibly be in conjunction with δ. The weather, however, is not completely fine." (12-inch reflector.)

"May 28th, 1803.—Near $\frac{1}{2}$ diameter of smaller. The diameters are full 2 to 1." (7-feet reflector.)

"January 29th, 1804.—I examined this star with powers from 527 to 1500, and saw it as a lengthened star, but not with sufficient clearness to take a measure of its position." (10-feet reflector.)

"May 22nd, 1804.—I cannot see the small star. The air is, however, a little tremulous. I tried 1500, but could not see it." (10-feet reflector.)

"May 29th, 1804.—20-feet reflector, powers 157 and 320. I cannot see the small star."

Herschel's observation of a slight elongation on January 29, 1804, was certainly an illusion, as the star had not closed up in less than a year. Unfortunately no diagram is given in the observation of May 1803, so we cannot get an estimation of the angle. I have some remarks on the failure of South, Secchi, and others to see this object on some occasions in the 'English Mechanic' for January 9, 1880. Mr. Franks has seen the *comes* perfectly with a 3¾-inch Wray and the same aperture on his 11½-inch speculum by Calver. It does not appear from Mr. Kirk's letter at what hour of the day he examined the star; probably he would see it double in daylight, though the bright twilight on the evening he looked at it ought to have rendered the companion clearly visible if his telescope was in adjustment. The angle and distance cannot now be very different from 318°·5 and 1″·68.

Yours faithfully,

Clapham, 1886, August 14. H. Sadler.

Gentlemen,—

In reply to the inquiry of the Rev. E. B. Kirk on p. 287 of your August number respecting the above binary, allow me to state that the companion is still visible, and that I have measured it on two evenings lately with the following results:—

$$\left.\begin{array}{l} P = 313^\circ{\cdot}0 \\ D = \;\;\; 0''{\cdot}8 \end{array}\right\} \text{Ep. } 1886{\cdot}629.$$

It is, however, more difficult than last year.

St. Paul's Vicarage, Alnwick, 1886, August 19. Yours faithfully,

Jevon J. Muschamp Perry.

Gentlemen,—

Although it may seem strange that Mr. Kirk (as stated in his letter to the 'Observatory' of June 30) should have failed to see the "comes" to this well-known double with an aperture of 6½ inches, as it is quoted as a defining test for a 4-inch achromatic, I think it may be readily explained if the star was observed on a *dark sky*. Under these conditions it is very frequently a difficult object, as the small star, either from its colour or some other cause, will bear but little magnifying and is very easily overpowered on a dark background. I obtained two measures of it during the past season with the 10-inch Calver, the mean of which gives

P.A.	Dist.	Epoch.
317·7	1″·66	1885·5

and one other this year, which I append:

P.A.	Dist.	Epoch.
318°·3	1″·71	1886·435

The two first were made with daylight sufficient to see the wires, and in twilight (shortly after sunset) I have readily seen the companion with the central 6 inches of my mirror. From a comparison of all the measures I possess and have access to, it would appear that the angle since 1862 has been steadily diminishing while the distance has remained fairly constant; probably that given in the last measure is too large, the night being too windy for distance. I may add that I find the lowest power which will readily separate the components gives the best view of the small star, but it is essentially a pair for good weather.

Yours faithfully,
KENNETH J. TARRANT.

1886, Aug. 2.

Companion Comets.—II.

GENTLEMEN,—

The question of Companion Comets seems to me to derive a twofold interest from recent observations and speculations on the subject. In the first place, on Mr. Proctor's theory of ejection we would naturally expect a considerable degree of similarity in the elements of two comets ejected from the same star and moving in a conic section round the Sun; for, considering the great distance even of the nearest fixed star, the orbits (unless much perturbed by planetary attraction) would be nearly parabolic, the Sun being in the focus and the orbit passing through the generating star, which might perhaps be thus identified. Secondly, the question derives a further interest from Mr. Denning's observations on persistent meteor-radiants. Meteor-showers having been in some instances connected with comets, it is not unreasonable to suppose that the connection extends further than has hitherto been observed; and if a family of comets was attended by a corresponding family of meteors, a shower from nearly the same radiant (assuming, as I have already contended, that the observed radiant is the true one) might continue for a considerable time. This would be rendered more probable if the shower was an intermittent one, and it would appear that most of Mr. Denning's long-continued showers are intermittent. One of the meteor-streams distinctly connected with a comet is the August stream, which has been traced to the third comet of 1862. But Mr. Denning has shown that this meteor-stream lasts for about a month, during which time there is a change in the direction of the radiant which, though small from night to night, is on the whole considerable. Now the comet in question seems to me to be one of a family which may, perhaps, afford an explanation both of the long continuance and of the change. I give the members of this family, so far as I am aware of them, in order of time:—

		π.	☊.	i.	q.	μ.
		° ′	° ′	° ′		
XI.	Comet of 1299	3 20	99 32	68 57	0·318	Retrograde.
	Comet of 1337 i.	2 20	93 1	40 28	0·828	„
	Comet of 1764	15 14	120 4	52 53	0·555	„
	Comet of 1787	7 44	106 51	48 15	0·349	„
	Comet of 1799 i.	3 39	99 32	50 56	0·840	„
	Comet 1862 iii.........	344 41	137 26	66 25	0·963	„
	Comet of 1870 i.	303 32	141 44	58 12	1·009	„

It should be stated, however, that all these comets (if their elements were correctly computed) passed the node before any of the August meteors were observed, except those of 1764, 1862, and 1870.

I conclude by sending a few more sets of companions.

		π.	☊.	i.	q.	μ.
		° ′	° ′	° ′		
XII.	Comet 1850 i.	273 24	92 53	68 12	1·0815	Direct.
	Comet 1874 iii.........	271 7	118 44	66 21	0·6757	„
XIII.	Comet 1846 vi.........	240 7	260 28	30 24	1·5287	Retrograde.
	Comet 1855 iii.........	237 36	260 15	23 7	0·5678	„

The comet of 1362 may belong to this set.

XIV.	Comet 1844 ii.	180 34	31 39	48 36	0·8553	Retrograde.
	Comet 1853 ii.	201 53	40 57	57 44	0·9044	„

The comet of 1832 ii. may belong to this set.

XV.	Comet 1849 iii.........	267 3	30 31	69 59	0·8946	Direct.
	Comet 1748 ii.	278 47	33 8	67 3	0·6253	„
	Comet 1850 i.	273 24	92 53	68 12	1·0815	„
XVI.	Comet 1846 iv.........	90 27	77 33	85 6	0·6637	Direct.
	Comet 1863 iv.........	94 43	97 29	78 5	0·7066	„
XVII.	Comet 1798	49 27	329 15	50 40	0·5266	Retrograde.
	Comet 1806 ii.	97 2	322 19	35 2	1·0815	„
	Comet 1808 ii.	69 12	322 58	45 43	0·3898	„
XVIII.	Comet 1769	144 11	175 3	40 45	0·1227	Direct.
	Comet 1786 ii.	159 25	194 22	50 54	0·4104	„
	Comet 1804	148 53	176 49	56 44	1·0772	„
XIX.	Comet 1790 iii.........	273 43	33 11	63 52	0·7959	Retrograde.
	Comet 1825 i.	273 55	20 6	56 41	0·8891	„

The comet 1822 iv. may belong to this set.

XX.	Comet 1780 i.	246 35	123 41	54 23	0·0963	Retrograde.
	Comet 1780 ii.	246 52	141 1	72 3	0·5152	„
	Comet 1793 i.	228 42	108 9	60 21	0·4034	„

The comet 1770 ii. may belong to this set.

In some of these instances what I take to be companions may be returns of the same comet, while in others comets which I take to be the same may prove to be companions. Thus I should be disposed to identify the comets of 961, 1558, and 1854 iv., one return of this comet about the year 1260 having been missed; but they may be companions, bearing a more distant relationship to the comets of 1500 and 1847 iv. Again, I am disposed to identify the comets of 1701 and 1792 ii.; but they may be companions (a supposition rendered more probable by the non-appearance of the comet in 1883), and the comet of 1766 may belong to the same family. Other comets are of rather a puzzling character. Those of 1853 iv., 1870 iii., and 1873 vi., for example, are all retrograde comets, agreeing closely in the longitude of the perihelion and the inclination, but exhibiting considerable differences in the other elements.

Truly yours,

Dublin, 1886, July 22. W. H. S. Monck.

P.S.—Since writing the foregoing I have seen Mr. Lynn's and Mr. Evans's letters in the 'Observatory' for August. I have to thank the former for the information thus afforded and I concur in his conclusions. But Mr. Evans surely makes a strange mistake when he says that the period of Tempel's and other comets "oscillates about *twice* that of Jupiter." Twice should of course be one-half, and with this correction I think the argument for the identity of the comet of 1766 with Tempel's comet of 1867 is strengthened. Taking the mean period of Tempel's comet of 1867 at half that of Jupiter, 8½ revolutions of Jupiter will be equivalent to 17 of the comet; and taking Jupiter's period at 11·86 years they will occupy 100·81 years, which approaches very closely to the interval between the perihelion passages of the comets of 1766 and 1867. I may remark that Prof. Newcomb, in the table at the end of his 'Popular Astronomy,' makes the period of this comet 6·00 years.—W. H. S. M.

Aurora and Spectrum.

Gentlemen,—

On the night of July 27 there was a fine aurora visible here. Pale yellow streamers seemed to radiate from an arc near the zenith; this arc extended from Vega to α Cygni. Sometimes the streamers broadened into fringes, which seemed suspended in the air directly overhead, and hung perpendicularly from the arc. The radiating appearance I suspected to be merely the effect of perspective.

The display lasted, as far as I observed, from $10^h\ 25^m$ P.M. to $10^h\ 40^m$ P.M.

Not more than half the sky was at any time occupied by streamers, but all parts gave a faint auroral spectrum, consisting everywhere of the usual bright auroral line with a faint band near F, sharply terminated on the side of the red end of the spectrum, and fading gradually towards the violet; also I suspected a very faint band near G.

Between the bright line and the band near F, I observed a number of lines which fluctuated in brightness, sometimes one or two flashing out very clear and again fading. Some years ago I observed and described the same effect.

No change in colour in the streamers was observed.

Yours faithfully,

Barrhead, Scotland, 1886, July 28. EDWARD BRUCE KIRK.

Universal Time.

GENTLEMEN,—

The spirit underlying the protest and recommendation made by Mr. Backhouse in his letter in the 'Observatory' for August, p. 288, is but too obviously that which animated the heroes of the familiar poem, in which we learn that

> "Lord Chatham, with his sword drawn,
> Stood waiting for Sir Richard Strachan;
> Sir Richard, longing to be at 'em,
> Stood waiting for the Earl of Chatham."

We are, says your correspondent in effect, to delay a valuable reform until somebody else, who is waiting for others to begin, shall himself commence it.

All honour, I say, to Mr. Christie for the action he has taken in the matter, and for the practical manner in which he has shown the ease, simplicity, and other patent advantages of the new mode of reckoning time. Had he deferred any action until M. Lambin, Herr Faulenzer, Signor Dilli Dalli, and Professor Tarre D. Grade had made up (what serves them for) their minds in this matter, the change would assuredly have been made in the Greek Kalends, and not one instant sooner. It required some public-spirited astronomer of influence and position to initiate the reform, if it were only to show its feasibility and the adaptability of the new chronological system at once to civil and scientific purposes; and the Astronomer Royal proved himself equal to the occasion.

If the nation which publishes the 'Nautical Almanac' will adhere to the improved method, I have but little fear indeed about others adopting it by 1891, if not, in fact, sooner.

Faithfully yours,

Forest Lodge, Maresfield, Uckfield, WILLIAM NOBLE.
1886, August 7.

Bright Aurora.

GENTLEMEN,—

Some mention may be made of the vivid auroral display here on the evening of July 27, as no other display has occurred since January 9, and only one worthy of the name last year. At 10.20 it stretched from N.N.W. to Cassiopeia in the N.N.E. Columns kept repeatedly ascending along this length. Afterwards a bright and well-defined arc of light formed. The red shading during the whole phenomenon was very slight indeed. Occasionally an unusually bright patch of light showed itself. An hour afterwards nothing was remaining but a brightness beneath Ursa Major. At 10.30 a meteor = 1 magnitude (very red) crossed the aurora from λ to ψ Ursæ Majoris.

Melplash Vicarage, Bridport,
1886, August 16.

Faithfully yours,
S. J. JOHNSON.

Royer and the Constellations.

GENTLEMEN,—

In my letter of the 3rd of May last (published in your number for July), I pointed out that several books on astronomy are in error in attributing the naming of some of the constellations in the southern hemisphere to Halley, who, in point of fact, introduced only one new group, that called Robur Carolinum, *i. e.* the famous Boscobel oak, which had even then ceased to exist on earth, and was transported by him to the heavens in honour of the shelter and concealment it had afforded to Charles II. when a fugitive in 1651. But I was myself in error in stating (p. 256) that Halley had adopted the names of some other constellations from Royer, the rarity of whose book must be my excuse for having too hastily accepted what is said about his nomenclature in several astronomical works. Will you allow me space now to state the true facts of the case?

Augustin Royer was architect to Louis XIV., and published in 1679 a small work containing four maps of the stars, with an introduction and catalogue. He tells us that after spending twelve years upon it, difficulties arising from his little experience in astronomy had nearly led him to abandon the idea of publication, when he was pursuaded to resume it by several friends, particularly Father Anthelme of Dijon (the discoverer of the new star in the neck of Cygnus in 1670), who afforded him very efficient assistance in the production. Just as it was about to appear, Halley's Catalogue of southern stars observed at St. Helena came into his hands, and he decided to give a reprint of this, with a French translation of the introduction, in the same volume with his own work. Neither the R.A.S. nor the R.S. possesses a copy of the volume in question, but there is one in the library of the British Museum. Two new constellations only were formed by Royer, neither of which has met with general acceptance—Sceptrum, to indicate the Hand and Sceptre of the French King, and Lilium, for the Fleur-de-lis of France. The former was inserted between Cepheus and Pegasus, the latter just over the back of Aries.

As regards the other constellations sometimes stated to have been named by him, they are found also in Halley, who, however, evidently uses them as names which had already been recognized.

Columba, I need hardly remark, he calls Columba Noachi, and those who first gave that designation must have considered Argo as a sort of Noah's ark, into which the dove was returning with its olive-branch. There was no occasion to destroy any part of the ship for it, as Halley did for his "Robur Carolinum." The Southern Cross (as it is now termed in ordinary parlance), which adheres to the hind legs of Centaurus, was formerly always called simply Crux. Bayer marks it as a subordinate group on his map of Centaurus, affixing to the four principal stars (which we, after Lacaille, call α, β, γ, δ Crucis) the letters ϵ, ζ, ν, ξ (*i. e.* Centauri). In the description he says:—" ϵ, ζ, ν, ξ Modernis Crux, Ptolomæo pedes Centauri." Perhaps I may point out that, in reforming Bayer's lettering of some of the southern constellations, Lacaille interchanged the places of β and γ Centauri (the former being a much brighter star than the latter), so that, whereas α and γ were pointers to Crux, α and β have been so since his time. Jacob Bartsch (Kepler's son-in-law), in his 'Planisphærium Stellatum,' which was published in 1624, includes both Columba and Crux in his constellations. Bayer does not mention the former, although he states that Argo is by some called Noah's Ark.

Yours faithfully,

Blackheath, 1886, Aug. 18. W. T. Lynn.

P.S.—It is well known that Dante has been thought to refer to the stars of the Cross in the first Canto of 'Il Purgatorio,' where he speaks of four stars near the south pole which had never been seen by mortal eye since the time of our first parents. To their configuration, however, he does not allude; but if an account of their existence had reached him, their brilliancy must have been greatly exaggerated, since he goes on to express sympathy with the inhabitants of northern climes for never having seen them.—W. T. L.

The former Variability of 34 *Cygni.*

Gentlemen,—

It is stated in many books on astronomy that the star in the breast of the constellation Cygnus, known as P or 34 Cygni, is a variable with a period of about eighteen years. This was the conclusion formed by E. Pigott about a hundred years ago (Phil. Trans. for 1786, p. 201) from a consideration of all the observations made in the seventeenth century. He states that he could not learn anything respecting change of brightness in it since the close of that century; and that from his own observations, between 1781 and 1786, he did not notice with certainty any variation in it (the magnitude being constantly the sixth), excepting that he finishes with the remark, "Sometimes I suspect it has rather decreased within these two last years, though in a very small degree."

Modern observations show no change of any kind since that time, so that during the present century, at any rate, the star has exhibited no sign of variability. This star, therefore, offers a very remarkable instance of one which, after being first noticed by William Janson in 1600, underwent several irregular changes of brightness during the following century, and has remained of the same, or very nearly the same, magnitude ever since.

It does not appear that Kepler noticed any change in it after his attention was called to it in 1601, when it was of the third magnitude and continued so for many years. It may interest some of your readers to quote Bacon's expression with regard to it, who, in the seventh chapter of his 'Descriptio Globi Intellectualis' (which must have been written in 1612), after alluding to the famous star of Hipparchus, says, "Etiam conspici nuper cœpit stella nova in pectore Cygni, quæ jam per duodecim annos integros duravit, ætatem cometæ (qualis habetur *) longo intervallo supergressa, nec adhuc diminuta aut adornans fugam."

We may hope that the new methods of stellar photometry which enable astronomers to take account of and register smaller variations of light than was possible before, will obtain for us some further information respecting this once remarkable star.

Yours faithfully,
W. T. Lynn.

Blackheath,
1886, August 12.

NOTES.

The Rainband†.—Some four years ago we printed in the 'Observatory' (Vol. v. pp. 42 *et seq.*) a paper by Mr. Rand Capron entitled "A Plea for the Rainband." Mr. Capron has now republished that paper in book form, together with some further remarks on the same subject. The object of this second part is to show that though the first novelty has warn off, rainband spectroscopy has been making real progress. To prove this, Mr. Capron briefly glances at recent discussions on the question which have appeared in the 'Times' and in 'Nature,' gives a list of some of the principal pamphlets or articles published on the subject, remarks on the increased use of rainband spectroscopes, and discusses a number of observations. A description of Klinkerfues' weather compass and a couple of letters on Atmospheric Electricity conclude this little volume, which although no particular pains have been taken to make it a finished literary work, yet cannot fail to be of much value to meteorologists wishing to use the spectroscope to the best advantage for weather forecasts. It is fully illustrated by a number of plates and diagrams besides the original one of the "Rainband in a Spectroscope of Moderate Dispersion."

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* Bacon seems to have thought that the stars of 1572 and 1604 were also comets.

† 'A Plea for the Rainband, and the Rainband Vindicated.' By J. Rand Capron, F.R.A.S., F.R. Met. S. London: Stanford, Charing Cross.

THE VISUAL SOLAR SPECTRUM IN 1884*.—Throughout the year 1884 a curious so-called "corona" was observed round the Sun—a broad whitish glare, which was seen even more distinctly when the Sun was at its greatest height. This "corona," together with the remarkable red "after-glows" of the same period, were very generally believed to be due to the vast quantities of impalpable dust which had been driven up into the higher regions of our atmosphere by the great explosion of Krakatoa. Prof. Piazzi Smyth having received a fine diffraction grating from Prof. Rowland, determined to completely map out the visible spectrum with the purpose, amongst others, of affording a means for ascertaining whether this "corona" was attended with any appreciable alteration in the solar spectrum. Edinburgh being too smoky for such a research, Prof. Smyth chose the neighbourhood of Winchester for his observing station, and, during the months of June and July 1884, made three independent surveys of the entire spectrum from A to beyond *h*. The results of these observations have been published in a series of 60 plates in the 'Transactions of the Royal Society of Edinburgh,' Vol. xxxii. part iii., each plate containing five representations of the same portion of the spectrum, the first two usually from the maps of Angström and Fievez, the last three the three independent charts drawn out from his Winchester observations by Prof. Smyth himself. The plates are coloured, each being of a homogeneous tint, so as to give a rough but not an exact representation of the actual colouring of the spectrum. The scale employed is that of wave-frequency to the British inch, but a tenth-metre scale of wave-length is also added. The reasons for adopting this scale and the method of colouring are given in the introduction in Prof. Piazzi Smyth's always felicitous and attractive style, and he certainly makes out a strong case both as to the employment of wave-frequencies instead of wave-lengths and as to the mode of arranging the spectrum the red end to the left of the page.

With regard to the comparison of the Winchester spectra with earlier observations, Prof. Smyth records a strong line at about λ 4733 which Fievez has not marked. He prefers, however, rather to consider this as probably an accidental omission from M. Fievez's chart than as evidencing the presence of a new gas in our atmosphere in 1884. The red and violet ends of the spectrum, however, showed a marked general dulling, such as should arise from the upper air being laden with minute opaque particles—"whether from the Krakatoa explosion or any other source."

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* "The Visual (Grating and Glass Lens) Solar Spectrum in 1884." By C. Piazzi Smyth, F.R.S.E., and Astronomer Royal for Scotland. From the 'Transactions of the Royal Society of Edinburgh,' Vol. xxxii. part iii. Edinburgh: Neill & Co.

ASTRONOMICAL PHOTOGRAPHY*.—Writing to Admiral Mouchez relative to the proposal for completing a photographic survey of the sky, Dr. Gill suggests that there should be a meeting of astronomers interested in the subject held during the spring of 1887, to consider the details of the work. Premising that for such a work as a general photographic map of the heavens, in which observatories in different parts of the world will cooperate, it is premature to consider the details of instruments and methods, Dr. Gill nevertheless expresses his preference for a telescope of large aperture, for instance a refractor of 24 inches. With this aperture stars of such a magnitude as with an aperture of 12 inches require an exposure of an hour would be photographed in 15 minutes. So that not only could an observer do four times as much work if the sky were clear, but also photographs could be obtained during a short period of clear sky which would be entirely lost were an exposure of an hour's duration necessary. Photographs taken with a large object-glass have also an additional advantage arising from the circumstance that the shorter the exposure the less will the positions of the stars be affected by differential refraction, and the effect of this refraction can be more easily computed. The star-disks are also better defined, and so more suited to measurement when the time of exposure is short. Dr. Gill also thinks that efforts should be made to publish by photography copies of all the plates—a work which might be finished in 25 or 30 years from the present time. Such a publication would place every astronomer who possessed a copy on paper in almost as advantageous a position as one possessing the original glass negatives. The result of the photographic survey contemplated by Dr. Gill would be that long before the year 3000, or even before 2000, we would have complete catalogues of all the stars visible on the plates rendered available by the labours of astronomers all over the world.

Admiral Mouchez expresses his concurrence with Dr. Gill's views as to the expediency of using large apertures for this work, and points out that all inconvenience arising from difficulty in manipulating large instruments can be obviated by adopting the form of equatoreal known as the "équatorial coudé."

THE OBSERVATORY OF YALE COLLEGE.—In the Report of this Observatory for the year ending June 1, 1886, Dr. W. L. Elkin, astronomer in charge of the heliometer, states that further observations of the Pleiades have been obtained, completing the series observed in the previous year. All these stars have now been observed on from 10 to 12 nights, and a total of over 1600 measures of distance and 700 of position-angle are available for discussion. The reductions are in a forward state and there remain only one or two points of detail to be disposed of before the definitive results can be deduced. With regard to the scheme for determining the average parallax of the first magnitude stars, Dr. Elkin proposes to take the ten brightest stars in the northern hemisphere and observe them each from 16 to 20 times at epochs of maximum parallactic displacement, using a favourably situated pair of comparison stars. It is not, of course, expected that each individual resulting parallax will be of very great accuracy from so limited a series, but it is hoped that the mean of the ten parallaxes will give a fairly reliable value for the average distance of the most brilliant stars. On account of the large proper motion of Arcturus it is of special interest; and Dr. Elkin has paid more particular attention to it, using six pairs of comparison stars, five of which have been successfully followed up so far. During the past winter Mr. A. Hall, Jun., has been engaged in observing with the heliometer, the object in view being a determination of the mass of Saturn from measures of Titan. He has also observed various stars for an independent determination of the instrumental constants, and has investigated the division errors of the part of the scale used in the observations of Titan.

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* 'Bulletin Astronomique,' tome iii. p. 321.

VARIABLE STARS.—Mr. T. E. Espin has issued Circular No. 6 of the Liverpool Astronomical Society, in which the following announcements are made:—

(1) The star D.M.+8° No. 3780, announced in circular No. 2 as being probably *Var.*, passed its maximum about June 4th, at which time its magnitude was 6·8. Since this date it has diminished in brightness, and on August 20th it was only 8·2. The star would seem to be a Long-period Variable. Its place (1885) is $18^{h}\ 32^{m}\ 51^{s}\ +8^{\circ}\ 43'{\cdot}5$.

(2) Variation has also been detected in the Red Star B. 535 (D.M.+47° No. 3031). The star passed a minimum about the end of April. On May 14th it was only 8·9, since which it has increased and is now 7·7. This star also is a Long-period Variable. Its place for 1885 is $20^{h}\ 5^{m}\ 58^{s}\ +47^{\circ}\ 28'{\cdot}9$. It precedes 32 Cygni by $5^{m}\ 57^{s}$ and is 9′ N. of it.

OBITUARY.—We regret to record the death of the Rev. Stephen H. Saxby, M.A., which occurred on August 5, after a lingering illness. He was the first incumbent of All Saints, Clevedon, and had held the living for 26 years; his manly sympathy, uniform courtesy and urbanity alike to rich and poor had endeared him to all classes in his parish. Of late years Mr. Saxby had devoted his entire leisure to astronomy, and in November last was elected a Fellow of the R. A. S. He has been cut off at the outset of what had promised to be a most fruitful career. We ourselves are indebted to him for several valuable papers (see 'Observatory,' Jan. 1883 and Nov. and Dec. 1885). He was born in 1831 and graduated at Gonville and Caius College, Cambridge, of which he was a scholar, in 1854. Among his published works were 'A Prize Essay on the Pew System' and 'The Birds of Shetland."

The Longitude of the McGill College Observatory [*].—Prof. W. A. Rogers and Prof. C. H. McLeod have recently determined the difference of longitude between the Harvard College Observatory and that of the McGill College, Montreal. Assuming that the centre of the dome of the Harvard College Observatory is $4^{h}\ 44^{m}\ 30^{s}{\cdot}993 \pm {\cdot}041$ west of Greenwich, the result of the discussion of the very elaborate series of observations made by Profs. Rogers and McLeod is that the pier of the transit instrument at the McGill College Observatory is $4^{h}\ 54^{m}\ 18^{s}{\cdot}543 \pm {\cdot}043$ west of Greenwich.

The Hongkong Observatory.—Dr. Doberck, the Government Astronomer, has published his observations and researches made at the Hongkong Observatory in the year 1885. These are for the most part confined to magnetical and meteorological subjects, but Dr. Doberck appears also to have spared no pains to make the Hongkong time-signal service as complete as possible, the main purpose of the astronomical branch of the Observatory being the determination of local time, although instruments are also available for making observations of such astronomical phenomena as happen to be particularly conspicuous in that region. The Observatory is provided with a 3-inch transit instrument by Troughton and Simms and with the "Lee" equatoreal described by Admiral Smyth in the 'Celestial Cycle,' the aperture of the object-glass of which is 6 inches. We congratulate Dr. Doberck on the success which has attended his efforts to establish an observatory at Hongkong and to publish the observations made thereat, and hope that he will be enabled to carry on the good work which he has begun so well.

The Progress of Astronomy in the Year 1885 [†].—The Annual Review of Astronomy, appearing in the 'Smithsonian Report,' has hitherto been compiled by Prof. Holden, and that for the year 1885 was also prepared by him in manuscript. During the transfer of Prof. Holden's library from Madison to California, however, all but a small portion of this manuscript was lost. Under these circumstances, Prof. Holden asked Mr. W. C. Winlock, of the Washington Observatory, to make up the deficiency, and thus the Report on the progress of astronomy in 1885 appears as Mr. Winlock's work, who has put the circumstances on record in order that he may plead the brief time available as an excuse for any shortcomings that may be found. As in previous years, free use has been made of reviews &c. in periodicals, particularly those in the 'Observatory,' 'Bulletin Astronomique,' 'Nature,' and 'Science,' and it may be remarked that although the report is primarily intended for those who have a general rather than a special interest in the progress of astronomy, it may be of use to professional astronomers also, as a convenient collection of reviews and notes. As far as we have examined the report, it appears to have been very judiciously compiled, and to fully maintain the character of the similar papers appearing in previous issues of the 'Smithsonian Report.'

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[*] 'Transactions of the Royal Society of Canada,' section iii. 1885.

[†] From the Smithsonian Report for 1885.

THE TOTAL SOLAR ECLIPSE OF AUGUST 29.—We learn by telegram from Grenada, dated August 16, that the British observing party has arrived there and has divided into two. Messrs. Lockyer, Turner, Perry, and Maunder are going to Green Island and Grenville Bay, on the east side of Grenada, and to Carriacou, a small island to the north. Messrs. Darwin, Thorpe, Schuster, and Lawrance will take up their station at Prickly Point, Hog Island.

A CORRECTION.—Mr. J. R. Sutton writes that in his letter on "Algol's Hypothetical Satellite" ('Observatory,' Vol. ix. page 286) the words "and taking the respective densities to be the same" should be erased from the eleventh line.

IN No. 2739 of the 'Astronomische Nachrichten' Dr. Dreyer of the Armagh Observatory has a short note "On the Invention of the Sextant." His purpose is to show that Hadley invented this instrument quite independently of Thomas Godfrey of Philadelphia, who made such an instrument of wood in 1730.

The same number contains a series of observations of Comet 1881 III., made at Pulkowa, and also a series of Comet 1884 III. (Wolf).

MINOR PLANET No. 259 has been named Aletheia by Prof. Peters of Clinton, U. S. A.

WINNECKE's periodical Comet was found at Cape Town on August 20. Its place at $5^h\,47^m\,54^s$ G.M.T. was R.A. $13^h\,10^m\,21^s\!\cdot\!5$, Dec. 1° 8′ 17″ South.

Elliptic Elements of Comet 1886 (*Brooks* 3).

By Dr. S. OPPENHEIM*.

T=June 6·815958, Berlin M.T.

ω	176° 50′ 13″·3
☊	52 5 56 ·2
i	13 23 48 ·0
log q	0·133357
log e	9·836962
log a	0·637824
U	9·05 years.

* Astron. Nachrichten, No. 2739.

OCTOBER, 1886. [*Price* 1s.

E OBSERVATORY,

ONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
hic Determinations of Stellar Positions. By B. A. Gould, For. R.A.S. ... 321
tes. By W. F. Denning, F.R.A.S. ... 326
scopes v. Small. By Prof. C. A. Young, Ph.D., For. Assoc. R.A.S. 328

dence:—

By Victor Nielsen, P. S. Yendell, and Rev. Jevon J. Muschamp ... 329, 330
d Meteors. By W. H. S. Monck, M.A., F.R.A.S. ... 331
of Venus by the Sun. By the Rev. S. J. Johnson, F.R.A.S. ... 332
tion of a faint Star. By Prof. J. G. Porter ... 332
of Mercury-trough.—New Variable. By R. L. J. Ellery, F.R.S. 333
ne of a Telescope. By Dr. F. Terby ... 334
id Shower. By T. W. Backhouse, F.R.A.S. ... 335
Time. By T. W. Backhouse, F.R.A.S. ... 335
omets. By W. C. Evans, M.A., F.R.A.S. ... 336
t Cometary Discovery. By W. T. Lynn, B.A., F.R.A.S. ... 336
tellation Solitarius. By W. T. Lynn, B.A., F.R.A.S. ... 337

r Eclipse, 1886, Aug. 29.—Dr. Huggins' Method of Photographing Corona.—Time Reform in Japan.—Publications of the Washburn rvatory.—New Comet.—Variable Stars.—Gould's 'Astronomical nal.'—Editorial Notes ... 338–344

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THE OBSERVATORY,

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Edited by E. W. Maunder, F.R.A.S., A. M. W. Downing, M.A., F.R.A.S., and T. Lewis, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpool Astronomical Societies; Articles by various eminent Astronomers, English, American, and Continental; Correspondence on topics of interest connected with the Science; Notes on the progress of Astronomy; Reviews of astronomical publications; Ephemerides of comets, variable stars, Saturn's satellites, and for physical observations of the Sun, Jupiter, &c.; and all the usual astronomical information.

Amongst the contributors to 'The Observatory' in 1885 were Professors Asaph Hall, Holden, Hough, Pickering, Pritchard, and Young; Dr. Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs. Barnard, Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"—*Bulletin Astronomique* (organ of the Paris Observatory).

CONTENTS OF No. 114.

PAGE

Articles:—

On Personal Errors in Double-Star Observations. By H. C. Wilson 297
Meteor Notes. By W. F. Denning, F.R.A.S. 301
The Variable Star L^2 Puppis. By A. Stanley Williams, F.R.A.S. 302

Correspondence:—

δ Cygni. By Dr. Copeland, F.R.A.S., Dr. F. Terby, F.R.A.S., H. Sadler, F.R.A.S., Rev. Jevon J. Muschamp Perry, F.R.A.S., and Kenneth J. Tarrant 304-308
Companion Comets.—II. By W. H. S. Monck, M.A., F.R.A.S. 309
Aurora and Spectrum. By the Rev. Edward Bruce Kirk 311
Universal Time. By Capt. William Noble, F.R.A.S. 312
Bright Aurora. By the Rev. S. J. Johnson, F.R.A.S. 312
Royer and the Constellations. By W. T. Lynn, B.A., F.R.A.S. 313
The former Variability of 34 Cygni. By W. T. Lynn, B.A., F.R.A.S. 314

Notes:—

The Rainband.—The Visual Solar Spectrum in 1884.—Astronomical Photography.—The Observatory of Yale College.—Variable Stars.—Obituary: Rev. S. H. Saxby, M.A., F.R.A.S.—The Longitude of the McGill College Observatory.—The Hongkong Observatory.—The Progress of Astronomy in the Year 1885.—The Total Solar Eclipse of August 29.—Editorial Notes 315-32

Elliptic Elements of Comet 1886 (Brooks 3). By Dr. S. Oppenheim 32

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 115. OCTOBER. 1886.

Photographic Determinations of Stellar Positions.*

THE early history of celestial photography is demonstrably and exclusively American; and its use as a method of delicate quantitative research is very markedly so. Without entering upon the historical data, which are of easy access to every investigator, I may mention that No. 77 of the 'Astronomical Journal' contained nineteen photographic impressions of as many different phases of the solar eclipse of 1854, May 26—the moment of each impression being given to the nearest tenth of a second. These were taken at West Point, under the direction of Prof. Bartlett, of the U. S. Military Academy, and form a part of his memoir, in which he also gives the distances between the cusps, as measured by himself with the micrometer in the telescope. Ten years later, in 1864, Mr. Rutherfurd constructed the 11¼-inch photographic object-glass which has acquired so conspicuous a place in astronomical history; and with this, in addition to its other achievements, he obtained sharp photographic stellar images with a definition previously unknown, taking for the first time distinct impressions of stars invisible to the naked eye—in fact, to the 8¾ magnitude for white stars.

After constructing a micrometer of great delicacy for the measurement of these plates, he measured with this the relative distances and position-angles of the stars which they contained. And in the spring of 1866 he kindly placed in my hands the results thus derived from three plates of the Pleiades, each containing two impressions, taken on the evening of March 10. One of these plates contained forty stars. Bessel's memoir upon the Pleiades, published in 1844, gave the relative positions of 54 stars, measured with the Königsberg heliometer, during the years 1829 to 1841. Six of these 54 do not belong within the limits of the plate (which contains about one square degree), and 10 of them are too faint for the photographic record, so that 16 of Bessel's list are wanting; but, on the other hand, there are two additional ones, not observed by him.

---

* Presented at the Buffalo Meeting of the American Association for the Advancement of Science, August 20, 1886.

From this fact alone it may be perceived that among the great benefits which astronomy may be justified in expecting from celestial photography, the accurate determination of magnitudes does not find place. The chemical action of the stellar light upon the film is so dependent upon the character of that light that, in the absence of a correct knowledge of its composition, we are very easily deceived regarding the amount. Thus one of Bessel's stars which was not recorded upon any of Mr. Rutherfurd's plates is estimated by Argelander as of the magnitude 8·0 and by Wolf as 7¾, while five are distinctly recorded which Argelander calls 8½ or less, and eight which Wolf so estimates. The spectroscope would doubtless show a deficiency of the more refrangible rays in the light of the former, and a preponderance of the same in that of the latter.

This series of measurements by Mr. Rutherfurd, together with the computations to which the results were submitted, constitute, if I am not mistaken, the first application of the photographic method to exact astronomical determinations. And the investigation necessarily demanded especial care, both for guarding the numerical results against sources of unsuspected error and for fixing the limits within which known theoretical errors would remain unappreciable.

The importance of the successful application of a method so different from all previous ones, and so full of promise, and also the considerable time which would inevitably elapse before the memoir could be printed, led me at the same time to communicate to the Astronomische Nachrichten, at Altona, some of the resultant values. In a comparatively short note, written about the middle of August 1866, I gave for the ten most conspicuous stars of the Pleiades, after Alcyone, the corrections derived from one of the photographic plates of March 10, for the values, published by Bessel, of the position-angles and distances from Alcyone in 1840; as likewise the average discordance found for a single measure.

In the next following year the Academy had not the means of printing its memoirs; and as, in the meanwhile, Mr. Rutherfurd had measured five more of the plates of the Pleiades previously taken, as well as six additional ones taken in the months of January and February 1867, these were also computed, and the results added to those from the first three plates in the memoir already written.

Various circumstances combined to delay the publication, chief among them being what seemed to me a manifest impropriety in printing the results derived from photographs and measurements made by Mr. Rutherfurd, and by his own methods, before some account of these methods should have been published by him. His communication on the subject had been made to the National Academy immediately previous to my own, but was not yet in such form as he desired for publication.

The result showed a very remarkable accordance with Bessel's determination for 1840, although the total amount of relative proper motion during the elapsed 26 years was comprised in the differences.

This memoir still remains in its original form, but unpublished; the results being deduced from 24 photographic impressions upon 14 plates.

In the next year, 1868, I had the gratification of receiving from Mr. Rutherfurd the results of his measurements of 32 stars of the cluster Præsepe, derived from 11 impressions. These were computed in the same way that those of the Pleiades had been, and an analogous memoir upon this cluster was prepared for the National Academy.

Before leaving the country, early in 1870, I gave these two memoirs to Mr. Rutherfurd, with the request that he would send them to the printer, at the same time with his own paper, already mentioned; but not before then. The condition of his health prevented him from attending to the matter for some time; and in the interval he arrived at the unpleasant discovery that the screw of his micrometer had suffered from wear, and to an extent which led him to fear a want of that accuracy of which the method is susceptible, and which he hoped to see demonstrated by its very first applications.

Notwithstanding this possible blemish, it seems to me that the results ought to be now made public in their original form, after due mention of the circumstances; and it is among my hopes to be able soon to publish these two memoirs from the original manuscript of so many years ago.

The method was received with manifest distrust and disregard abroad; and, as was but natural for so essential a deviation from former methods, very many grounds of criticism and objection were brought up. One of the principal of these was the possible distortion of the collodion film, after receiving the impressions and before the measurements; but Mr. Rutherfurd speedily disposed of this point, at least so far as the albuminized plates are concerned; and, moreover, the combination of measurements of the same stars derived from various plates will at once make manifest the degree of confidence to which the several values and their mean are respectively entitled.

A far more serious obstacle to accuracy is presented by the difficulty of obtaining absolutely round images. Irregularity of form in the dots formed by the stellar impressions is almost incompatible with precision of measurement; and, as the time of exposure must often be long, the chief problem was, not so much to obtain the images as to insure uniformity of motion in the telescope during the period of exposure. Not that the photographic processes were not troublesome enough before the introduction of the dry-plate processes, for very great care and numerous precautions were often necessary to prevent the plates from drying too fast; but far the greatest difficulty consisted in obtaining sufficient precision in the clockwork and equatorial motion of the telescope.

It may easily be imagined how great was my desire, when leaving home for South America, to extend this new method of observation to the southern hemisphere. But the obstacles encountered in the endeavour cannot be easily imagined. Upon these I will not enlarge here further than by saying that, in Cordoba, also, the attainment of circular dots for the star-images offered incomparably the greatest of all the difficulties of a practical character. The time of exposure was limited by the maximum size allowable for the large stars, and, previous to 1878, also by the drying of the plate, although exposures of twenty minutes were not unusual. Nevertheless, by dint of specially constructed governors and regulators, and by ceaseless attention, we did succeed in obtaining impressions which, to the unaided eye, appear absolutely round.

This necessity of long-continued and minute uniformity in the motion of the telescope is, of course, largely diminished by the employment of instruments of large aperture, inasmuch as the necessary time of exposure is diminished in the same ratio in which the amount of light is increased. It is yet further and most notably diminished by the manifold greater sensitiveness of the dry gelatine plates. But notwithstanding all this, the attainment of round images, while almost indispensable for giving to stellar photography that increased accuracy to which it may lay claim as a means of research in practical astronomy, still demands especial care and precaution.

The Argentine Government cordially afforded every assistance which I deemed it proper to ask for these investigations. And although the chief energies of the Cordoba Observatory were absorbed by those investigations for which the institution was established, I had the satisfaction of obtaining a sufficient number of stellar photographs to occupy not only my own lifetime, but many more, in their measurement and proper computation.

We photographed no northern stars there, except the Pleiades and the Præsepe. Of the Pleiades I brought home sixteen plates, with two impressions of the whole group upon each, made in five different years, from 1872 to 1882, inclusive. Although the centre of the cluster never attains a greater altitude at Cordoba than 34° 50′, some of the plates contain 70 stars. All but one of Bessel's stars are there, which belong within the limits of the field; the missing one being of the magnitude 9½, and there are yet other stars of the magnitudes 10, 10½, and 11. Of the Præsepe there are five plates, and with a correspondingly increased number of stars.

About seventy southern clusters have been repeatedly photographed at Cordoba, comprising all those of the southern hemisphere which seemed important; also somewhat more than a hundred double stars, being a sufficient number to serve as a good test of the method. The total number of photographs now on hand is somewhat less than 1300, only few having been preserved in which the images were not circular.

Especial attention, however, was given, for many years, to taking frequent impressions, at the proper seasons, of four stars, selected, on account of their large proper motion, as likely to manifest appreciable annual parallaxes. The refined and elaborate observations of Drs. Gill and Elkin, at Cape Town, have been made, computed, and published, while the Cordoba photographs have lain untouched in their boxes. There is but one of my four stars, β Hydri, which is not included in their list. Still it will be a matter of much interest to apply the photographic investigation to the same problem, even if for no other purpose than a comparison of the results of the two methods.

I am convinced that the Cordoba plates contain a large number of stars as faint as the eleventh magnitude of Argelander's scale, and believe that these are much the earliest photographs of stars fainter than Mr. Rutherfurd's of 1865 and 1866. There are several plates, covering about a degree square, which cannot contain less than 500 stars, and I believe that some of them contain a greater number. Such are those of the cluster Lac. 4375 and that near x Carinæ.

The region in the vicinity of η Carinæ, and that magnificent tract in Sagittarius which is too densely sown with stars to be considered merely a portion of the Milky Way, and yet too large and undefined to be regarded simply as a cluster, were both of them taken several times, during the years 1875 to 1882, in series of overlapping photographs, each containing about a square degree, and recorded upon a glass surface of 9 by 12 cm. In their present form they are of course of small value for scientific use, inasmuch as the stars are too crowded for their configurations to be easily perceived; and, although these two series form in fact maps of considerable regions in the sky, still the record is of a very perishable nature, and of small avail for use by astronomers until it shall have been translated into an enduring and numerical form by micrometric measurement.

In this connection I may say that one of the greatest of my present anxieties regarding the Cordoba photographs arises from a discovery of the ease with which the collodion or gelatine film may become detached from the glass. The Argentine Government has assigned a moderate sum for the prosecution of the measurements, and with this some progress has already been made. It is but right to add that the full amount was given for which I asked. Still it is now quite inadequate, in consequence of the unfortunate depreciation of the national currency; and, in the present financial crisis there, I cannot reasonably expect more. Yet this matter of prompt measurement appears to me at present much more important than it did while I was unaware of the facility with which the film can blister and peel.

In 1883, after Mr. Common's brilliant success in photographing nebulas with his great three-foot reflector, he proposed to me a joint arrangement for photographing the whole heavens. My work at Cordoba was so near its close that it was out of the question to undertake anything new; but the immense labour requisite for the measurement of the plates would, under any circumstances, have tended to deter me. It is an undertaking demanding the joint energy, application, and material resources of a large number of persons, if the results are to be made available for astronomical use; indeed, I see no other astronomical value in the unmeasured photographs than the possibility of confirming at some future epoch the existence of relative motion previously detected or made probable by some other investigation.

Since then the process of photographic charting is said to have been systematically undertaken by the Brothers Henry, at Paris. I have seen none of their plates; but their sharpness is highly spoken of, and the work appears to be prosecuted with much skill and very sensitive plates. There can of course be no question as to the value of any permanent record whatsoever, corresponding to a known date; yet I cannot feel that any essential advance is likely to be made in this way until the photographic record shall have been brought within the range of numerical expression.

The measurements of the Cordoba photographs, thus far completed, are those of the double stars, the four stars with large proper motion, of the Pleiades, of the Præsepe, and of the clusters Lac. 4375 and κ Crucis. The corresponding computations have been made, as yet, only for a portion of the Pleiades impressions, but I am hopeful of completing all these at a comparatively early date. We shall then be able not only to compare the results with Bessel's of 45 years ago, but to test the deduced values of the proper motions by means of the photographic determinations of 1865 and 1866. Meanwhile the valuable memoir of Wolf has been published, giving closely approximate positions for 571 stars of the group, and Dr. Elkin has recently been executing at New Haven a heliometric triangulation of the principal stars. Our photographic results will have to be confronted with his delicate heliometric ones; and should they bear this test with tolerable success, it will be all that can reasonably be desired. B. A. GOULD.

Meteor Notes.

THE large meteor observed here at $10^h\ 40^m$, Aug. 4, with a path from $129° + 60°$ to $83° + 40°$, appears to have been a very brilliant object in the north of England.

Mr. D. Booth, of Leeds, reports the motion as very slow and gives the path as from 265° +25° to 286¾° ±0°. Time 10^h 44^m.

Mr. William Davenport, near Halifax (long. 1° 49′ W., lat. 53° 42′ 30″ N.), describes the size of the meteor as about one third of the full Moon and says it travelled very slowly through a barren part of the heavens one third the distance between 72 Ophiuchi and ε Aquilæ and parallel with α and β Ophiuchi. It left no train. The observer heard an explosion like distant artillery about a minute after the meteor had disappeared.

"L. J. H.," writing from Ramsey, Isle of Man, refers to a fine meteor seen on August 4 at about 11^h. It commenced a little E. of η Aquarii and seemed to travel in the direction of a line joining η and δ. In 3^s or 4^s the meteor passed over 20°.

The most remarkable fact in connection with the meteor was its very slow motion. At Bristol it traversed an apparent path of 34° in 8 seconds, very carefully determined.

On August 24, in a watch of 2½ hrs., 19 meteors were observed here. There was a very definite little shower of rather swift meteors from the point 346° ±1°. I had seen this radiant on Aug. 16–20, 1885.

On August 27, 28, and 29, 73 meteors were noted during observations covering 9 hours. The sky, though free from actual clouds, was much involved in fog, especially at low altitudes, and thus many faint meteors must have escaped notice. By far the best shower in progress on those nights was from 292° +70° near δ Draconis. I found a radiant here in August 1878, but at the beginning of the month, and Heis's catalogue includes a radiant at 292° +70°, August 3–19, derived from 226 meteors. He also gives this shower for Sept. and Oct. Greg suspected a radiant at 287° +67° August, from British Association observations. The display is evidently one of fairly pronounced character, though it seems impossible to limit it to a brief epoch; there may be several showers succeeding each other from the same point. The meteors I observed this year belonging to these δ Cepheids were unusually bright, moving rather swiftly and leaving streaks, or thick trains so like the phosphorescent streaks as to be scarcely distinguished from them.

I was much interested in noticing during a watch of 5 hrs. on Aug. 29, a sharply defined radiant at 106° +52°. I believe this is the same shower as one at 105° +53°, which I deduced from Lieut.-Col. Tupman's observations for the period Sept. 6 to Oct. 4, 1869, and particularly referred to in 'Monthly Notices,' Vol. xxxvii. p. 350, as possibly connected with Donati's comet, which has a radiant at 100° +59° Sept. 8. The circumstances, however, render the suggested connection extremely improbable. The radiant of the star-shower is some 8° distant from the cometary radiant, and, apart from this, Donati's comet at the descending node on Sept. 8 passed some 18 millions of miles inside the Earth's orbit. Moreover, no specially rich display of meteors from this point in the

Lynx has ever been witnessed on Sept. 8; the shower rather appears to be spread over a long interval. The approximate agreement is therefore probably quite accidental. On Sept. 7 this year, watching a hazy sky for 2½ hrs., I counted 15 meteors, of which 2 were from the Lynx. There were also several streak-leaving meteors from 62° + 36° near ε Persei. I recognized this shower also in 1885; it formed the subject of a paper in the 'Observatory,' Vol. v. p. 262.

The finest meteor recently seen here was recorded at $13^h\ 39^m$ on Sept. 7. It was as bright as Venus and left a broken streak, after a very swift flight of 15° from 146° + 78° to 205° + 74°. Radiant probably at 100° + 73°, or perhaps in the head of the Lynx, close to the computed radiant of Donati's comet. W. F. Denning.

Bristol, 1886, Sept. 8.

Large Telescopes v. *Small.*

May I ask space for a few words in response to Mr. Denning's last interesting paper? I care to refer only to one or two points.

I am unable to agree with him in considering the central 9 inches of our 23-inch glass inferior to any 9-inch telescope of ordinary focal length. Of course the extra thickness of the glass involves a slight loss of light—possibly as much as 5 or 6 p. c., though I doubt it; this would be equivalent to the contraction of the 9-inch aperture by about $\frac{3}{10}$ of an inch. But, *per contra*, with the longer focus the outstanding chromatic aberration is greatly diminished, and the definition notably improved—more than enough to compensate for the slight loss of light, I think.

As to the Washington drawings of Mars, I am unable to see anything "astounding" in the case. I know but little about the ins and outs of the Observatory administration and the relations of its inmates at that time. But my impression is that the junior observer (Professor Holden) made his sketches at odd minutes when the telescope happened not to be actually in use by its regular employers, and that some time afterwards they were privately communicated to M. Terby, not for publication, but to be utilized in the preparation of his 'Aréographie.' Professor Harkness and he certainly worked independently, and each drew or tried to draw simply what he himself saw. The senior Professor, with the permission of the Superintendent I presume, communicated his results to the R.A.S., which saw fit to publish them. But they are not to be taken as the measure of what another observer could or could not have seen with the same instrument.

Mr. Denning hits the nail on the head when he calls attention to the great number of observers who use apertures ranging from 5 to 12 inches, as compared with those who command great telescopes—18 inches and upwards; 100 to 1 is certainly not too high. The users of the large telescopes, therefore, in the investigation of any object "run against the field," so to speak, and stand a heavy chance of defeat by some of their numerous competitors who can supplement the powers of a slightly inferior instrument with keener eyes, and perhaps a clearer sky. No size or excellence of telescope can make up for defective vision and a "boiling" air; but *with a given eye and atmospheric condition*, I am satisfied that the great telescope, if good, will always reveal more than the smaller one. In many cases it will of course destroy illusions and correct errors based upon a perfectly honest interpretation of features dimly seen, or supposed to be seen, by enthusiastic observers with smaller instruments. Feeble telescopic illumination, like twilight, is very stimulating to the imagination. But this elimination of illusions, instead of being deplored as a "cutting down" of knowledge, should be welcomed as a most real advance.

1886, Aug. 16. C. A. Young.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

δ Cygni.

Gentlemen,—

In your excellent review the 'Observatory,' Nos. 113 and 114, I have with much interest followed the discussion about δ Cgyni and the visibility of its companion. I cannot believe that Mr. Kirk could fail to see the comes if his reflector was in adjustment, as it is well seen with my excellent 5⅓-inch Reinfelder and Hertel refractor. The same object-glass gives also ζ Herculis in contact with power 144, and easily separated with power 216. These two stars, δ Cygni and ζ Herculis, are mentioned in Dr. F. Terby's letter as a "pouvoir séparateur" for his 8-inch Grubb refractor.

Yours faithfully,
Victor Nielsen.

Copenhagen,
1886, September 9.

Gentlemen,—

I notice in the current 'Observatory,' p. 287, a letter from Mr. Kirk concerning δ Cygni.

I have had some recent experience with this star in testing a new telescope by Mr. John Clacey of Cambridgeport, aperture 4¼ inches and 45 inches focal length; it easily divides such stars as π Aquilæ and λ Ophiuchi with power 180.

I was observing on the evening of July 24, the seeing was good, star-images small and quiet, and few diffraction-rings. I watched δ Cygni for some time without very definite results, until a thin cloud began to pass over it, when the disks were still further cut down, and I saw the companion plainly and steadily: this is the only time I have succeeded with it, but of this time I am very sure.

This morning I observed an occultation of α Tauri; the immersion occurred at $6^h\ 21^m\ 28^s$ standard time, power 90; the star seemed to hang on the edge or just inside for about two seconds, then disappeared instantaneously. The immersion occurred at the limb just opposite P. Smyth—the Moon being about south and the Sun one hour and twenty-one minutes high.

The emersion occurred at $7^h\ 6^m\ 58^s$.

The star was very conspicuous in both brilliancy and colour, the sky being clear, and no perceptible tremor in the air with power of 90.

The eyepieces used in both these observations were solid ones with powers 90 and 180, and ordinary negative of 1 inch equivalent focus, with field of a little over one degree.

Yours truly,
P. S. YENDELL.

Boston, Mass., U.S.A.,
1886, August 23.

GENTLEMEN,—

After sending you my measures of this star which appeared on p. 308 of your September issue, and before the appearance of that number, I discovered that there was a disarrangement in my micrometer which necessitated an addition of $0''\cdot 6$ to the distance. I had been away from home, and had not used the micrometer for some months previous to the measure, and did not discover the error till too late to correct it in your last issue.

Dr. Copeland, on p. 304, gives Behrmann's Ephemeris of this star from 1879 to 1890. I have measured it on several nights in the years 1880, 1882, 1883, 1885, and 1886. For purposes of comparison I give the means of my measures for these years; they are as follows:—

Behrmann..	P=325°·52.	D=1″·461.	1880.
Perry	P=327 ·00.	D=1 ·36 (4 nights).	
Behrmann..	P=322 ·35.	D=1 ·468.	1882.
Perry	P=325 ·30.	D=1 ·56 (3 nights).	
Behrmann..	P=320 ·57.	D=1 ·472.	1883.
Perry	P=320 ·00.	D=1 ·54 (3 nights).	
Behrmann..	P=317 ·43.	D=1 ·481.	1885.
Perry	P=318 ·20.	D=1 ·46 (4 nights).	
Behrmann..	P=316 ·70.	D=1 ·486.	1886.
Perry	P=315 ·00.	D=1 ·6 (3 nights).	

I always find about half an hour before sunset the best time for measuring this star.

Yours faithfully,
JEVON J. MUSCHAMP PERRY.

St. Paul's Vicarage, Alnwick,
1886, Sept. 10.

Comets and Meteors.

GENTLEMEN,—

The question of cometary radiants and meteoric orbits seems to have excited more interest in America than in this country and some tables of both have been published by Messrs. Corrigan and Wendell. The recognized connection of meteor-streams with comets in four instances led Mr. Corrigan to assume that meteors move round the Sun (as focus) in nearly parabolic orbits, and he showed how from the observed radiant-points of the meteors such orbits could be computed. The result of his calculations and those of Mr. Wendell, however, can hardly be regarded as satisfactory. Beyond the four cases already known, I think it may be said that no computed cometary radiant is found to agree with a known meteor-radiant, and no computed meteoric orbit agrees with a known cometary orbit. There are a few cases of possible identity, but apparently not more than chance would account for.

Some of the meteoric orbits computed by Messrs. Corrigan and Wendell are, moreover, a little startling. In three of Mr. Corrigan's orbits, the perihelion distances are 1·0127, 1·0057, and 1·0007 respectively. How, it may be asked, could meteors moving in such orbits enter the atmosphere at all? Mr. Corrigan no doubt took the mean distance of the Earth as his unit, and the first of these orbits is that of a meteor-stream which was seen when the Earth was nearly in aphelion, but the second was seen two months after aphelion. One of Mr. Wendell's orbits, however, is perhaps more directly in point. The stream was seen on the 2nd of January, and the perihelion distance is given at 1·000. But on the 2nd of January the Earth was nearly 1½ millions of miles nearer to the Sun than its mean distance.

More extensive examination may perhaps lead to more satisfactory results; but it occurs to me that the fruitlessness of Messrs. Corrigan's and Wendell's labours may have arisen from their assumption that the meteor does not partake in the motion of the atmosphere (*i.e.* of the Earth). And I venture to suggest through your columns to these gentlemen, and to your other readers who possess the requisite leisure and skill, that a computation of meteoric orbits based on the assumption that the meteor while visible partakes fully in the Earth's motion might lead to further identifications. At all events this assumption deserves a trial before the hypotheses that meteors move round the Sun in nearly parabolic orbits is abandoned.

For a full examination of the subject we require two catalogues, neither of which (as far as I am aware) exists at present:—1st. A complete catalogue of comets giving the corresponding radiant-points calculated (*a*) on the assumption that the cometary meteors participate in the Earth's motion, and (*b*) on the assumption that they do not so participate. 2nd. A catalogue of observed meteor-radiants, omitting none that have been observed (or are believed to have been observed), for theoretical reasons. When we want to test theory by observation we must not commence by cutting down observation to suit theory. Examination will probably lead to the rejection of some meteor-radiants which are supposed to have been observed, but they should be rejected as a result of examination, not as a preliminary to it. I remain, &c.,

Dublin, Sept. 6, 1886. W. H. S. MONCK.

Occultation of Venus by the Sun.

GENTLEMEN,—

The next superior conjunction of Venus and the Sun takes place at 17^h on December 2nd, according to the 'Nautical Almanack,' when the declination of the Sun is 22° 6′, that of Venus 21° 59′ S.

It seems a matter of some interest to notice how close to the Sun's limb the planet may be detected by some of the large instruments in different parts of the world.

The late Dr. Dick, of Dundee, seems to have been successful in this matter with comparatively inferior telescopes. After mentioning observations of the planet when very near the Sun's limb on 16th October, 1819, and 10th March, 1842, he gives an observation ('Practical Astronomer,' p. 474) on 2nd October, 1843, when he detected Venus only 58′ from the Sun's northern limb. His words may as well be quoted:—"Two hours before the conjunction I perceived the planet distinctly, and kept it in view for nearly ten minutes, till some dense clouds intercepted the view. It appeared tolerably distinct and well defined, though not brilliant, and with a round face, and its apparent path was distinctly traced several times across the field of view of the telescope. I perceived it afterwards about half-past four P.M., only a few minutes after it had passed the point of conjunction, on which occasion it appeared less distinct than in the preceding observation, owing to the low altitude of the planet, being then only a few degrees above the horizon." Dr. Dick's observations were not made with an equatoreal, but with an ordinary 2¾-inch telescope, and a terrestrial power of 95. A contrivance was adopted for intercepting the entry of the solar rays. Faithfully yours,

Melplash Vicarage, Bridport, S. J. JOHNSON.
1886, Sept. 10.

Proper Motion of a faint Star.

GENTLEMEN,—

An instance of proper motion even more remarkable than the one published in the August number of the 'Observatory' has just come to light in the course of preparation of our catalogue. The star is Oeltzen's Argelander No. 20452, magnitude 8·5.

The observations are as follows:—

	Epoch of observation.	α 1885·0.	δ 1885·0.
		h m s	° ′ ″
Lamont..........	1829·64	20 16 46·34	−21 41 12·9
„	1847·79	46·87	41 34·2
Wash. Zones	1848·57	46·90	41 35·2
O. Arg...........	1849·67	47·04	41 38·7
Cincinnati........	1886·12	48·52	42 19·6

The first observation will be found in Lamont's 'Observationes Astronomicæ,' Vol. vi., or new series Vol. i. The second is given in his zone catalogues.

The Washington observation is the mean of the Transit Circle and the Mural Circle observations, both made in 1848. The Cincinnati position is the mean of four determinations.

Applying the method of least squares, we obtain for the proper motions in right ascension and in declination respectively

$$+0^{\mathrm{s}}{\cdot}0396 \text{ and } -1''{\cdot}178.$$

Applying these we obtain:—

	α 1885·0.	δ 1885·0.
	h m s	° ′ ″
Lamont	20 16 48·53	−21 42 18·1
„	48·34	18·0
Wash. Zones ..	48·34	18·1
O. Arg.	48·44	20·3
Cincinnati	48·48	18·3

The motion on a great circle is 1″·30 per year. This star must therefore be added to the list of those whose proper motion exceeds one second a year.
J. G. Porter.

Cincinnati Observatory, Ohio,
1886, August 12.

Suspension of Mercury-trough.—New Variable.

Gentlemen,—

Since the erection of our new Transit Circle we have experienced difficulty in obtaining a sufficiently quiet state of the mercury surface used for our nadir and level observations to ensure thoroughly satisfactory results, and not unfrequently in frosty weather have had to wait hours for a cessation of minute tremors. I therefore determined some months ago to try the plan proposed by Admiral Mouchez in the December number of the 'Bulletin Astronomique,' and used successfully at the Paris Observatory. The mode hitherto adopted here was very similar to that used at Greenwich, namely a "mercury-bath" suspended by a system of india-rubber bands.

The Paris "bath" was first tried in May last, and after a few experiments for getting the right amount of flotation and freedom of screw of the inner vessel, we obtained highly satisfactory images, and on no occasion since have we been unable to obtain a really good observation. Every observer speaks in the highest terms of the improvement affected by the new "bath," and the rapidity with which any accidental disturbances come to rest. The thanks of all engaged in such observations are due to M. Mouchez for his description of the apparatus.

A new variable was accidentally found while observing Barnard's comet on May 31. Mr. White (chief assistant) in comparing the position of the comparison star with the nearest bright star, took what he believed to be β Leporis, but which he soon found was some distance from that star. The magnitude he estimated as a good fourth. This star could be found in no catalogue but Lalande's, where one corresponding exactly in position was recorded as of the 5·5 magnitude (Lal. 10063, R.A. $5^h\ 15^m$, N.P.D. 111° 21′). On June 4 it was seen in strong twilight with the naked eye, and estimated slightly brighter than β Leporis. Measured with Pritchard's wedge on the 6th it was found to be mag. 5·8 and was a close double (comes 10·5 mag.). Pos. 104° 40′, dist. 4″·18. The following gives the subsequent measures indicating short period changes also:—

	d	h	Mag.
June	6	6	5·8
	14	5·8	5·3
	30	5·5	5·7
July	6	18	5·0

These differences may, however, be due to the unfavourable conditions for observation (evening or morning twilight).

Yours faithfully,
R. L. J. Ellery,
Government Astronomer.

Melbourne Observatory,
1886, July 26.

Performance of a Telescope.

Messieurs,—

Je vous remercie du bon accueil que vous avez fait à ma dernière lettre dans l'*Observatory*. Permettez moi de vous prier de bien vouloir signaler à vos lecteurs quelques fautes d'impression:

P. 306, ligne 18, au lieu de OΣ 219, lisez OΣ 215.
19, „ γ Scorp. „ ν Scorp.
20, „ Σ 1999 „ Σ 1555.
34, „ Σ 2996 „ Σ 2556.

Depuis que j'ai eu le plaisir de vous écrire j'ai encore fait un certain nombre d'essais qui n'ont fait que confirmer l'excellence de mon objectif de Grubb. J'ai vu parfaitement, avec un grossissement de 150 fois environ, le compagnon de 14^e gr. de ε Pegasi, celui de κ Pegasi; j'ai dédoublé, déjà avec le même oculaire, OΣ 452; j'ai vu parfaitement le compagnon de 10^{e} gr. de 33 Pegasi, déjà avec le 150.

J'ai bien dédoublé, avec un grossissement de 280 environ, les *petits* couples suivant :

OΣ 445. Σ 2868, Σ 2934, OΣ 483, Σ 3012, Σ 3013, Σ 2478, Σ 2553. OΣ 508, Σ 3047, β 394 (Burnham), Σ 96, Σ 3057, Σ 3062. J'ai bien vu *triples* : Σ 262, avec le 280 et le 420, et OΣ 2 surtout avec 450. Enfin, quand le ciel est bien pur, je vois le compagnon de μ Andromedæ.

J'aurai le plaisir de vous tenir au courant des essais futurs que je ferai spécialement sur Saturne, pour éprouver la définition.

Je vous prie, Messieurs, de bien vouloir me croire

Votre bien dévoué,

Louvain, le 3 septembre 1886. Dr. F. Terby.

The Perseid Shower.

Gentlemen,—

It is probable that I saw the last of the meteors mentioned by W. F. Denning on p. 302. The following are the particulars of my observation here :—8mo. 10th, $13^{h}\ 33^{m}$–38^{m}. A very beautiful meteor = ♀ at its brightest. Directed from $\frac{2}{3}$ (γ, β) Piscium; passed $\frac{2}{3}$ (λ, σ) Aquarii. Course longish. Left a bright streak for 5 seconds.

I did not note the exact time.

On that night I watched for meteors for some time. At the time when the sky was darkest, there being only slight moonlight or twilight—viz. between $13^{h}\ 32^{m}$ and $14^{h}\ 14^{m}$—I watched for 21 minutes, during which time the meteors were at the rate of 78 per hour; the shower was therefore decidedly above the average in brightness.

Sunderland, 1886, Sept. 14. T. W. Backhouse.

Universal Time.

Gentlemen,—

Captain Noble has misunderstood the recommendation made by me in 'The Observatory,' p. 288, which was not that we should delay the reform till *somebody* else begins it (a course which I deprecate), but till *everybody* else agrees to do so—at any rate as regards the astronomical world.

Sunderland, 1886, Sept. 11. T. W. Backhouse.

Since writing the above, I learn that the Board of Visitors of the Royal Observatory have recommended that the 'Nautical Almanac' for 1891 should be calculated on the new time-reckoning. Of course my objections only partially apply to an alteration thus proposed by a national representative body of this kind, though I still think it would have been well to have obtained the agreement of other nations before making the recommendation.—T. W. B.

Periodic Comets.

GENTLEMEN,—

In my previous letter of course I intended to say that the mean motion of the comets mentioned and not their period was twice that of Jupiter.

The statement in Newcomb's 'Astronomy' as to the period of Tempel's Comet was, no doubt, simply based upon the motion between 1867 and 1879; if the present osculating value of μ, namely 545″, had been known, the statement would probably have been modified.

It must be remembered that the interval between a certain number of periods of revolution of the comet in question may differ from the interval due to mean period by nearly three years, and the same may be said *mutatis mutandis* of other comets. For the coefficients of the commensurable inequalities are in such cases almost at their maximum, not as in the case occurring in the theory of Jupiter's satellites, where the coefficient vanishes. So that it is by no means easy to determine within a year or two the time of perihelion passage for many periods in arrear of even the short-period comets.

Two-thirds the period of Jupiter is probably the mean period of both Faye's and Denning's Comet. The μ of Faye probably varies between 420″ and 478″, so that the coefficient of the commensurable inequality would be also considerable in this case.

Yours faithfully,
Sept. 20, 1886. W. C. EVANS.

Pons's first Cometary Discovery.

GENTLEMEN,—

In the early part of the year 1801, Lalande offered a prize for the first discovery of a comet, and on the 12th of July in that year one was discovered at Paris almost simultaneously by Messier, Méchain, and Bouvard. These astronomers, however, were anticipated by Pons, who discovered the comet one day before them, or on the 11th of July (Zach's 'Monatliche Correspondenz,' Vol. iv. p. 179). A claim, however, was some time afterwards set up by Herr Reissig, of Cassel, to have seen the comet on the 30th of June, or twelve days before Pons. In Mr. Chambers's well-known and popular 'Handbook' this claim is admitted, and Reissig is set down as the discoverer of the comet in question. The claim is made in a letter to Bode, which is printed in the 'Berliner Jahrbuch' for 1805 (published in 1802), p. 129. Reissig stated that he saw the comet on the 30th of June, and once afterwards (date not given), but that, on account of unfavourable weather, he was not able to obtain an observation of it, and that by August he believed it had ceased to be visible. On this Bode remarks:— "Diese Nachricht ist zu unvollständig, als dass man etwas sicheres daraus folgern könne. Der Preis von 100 Laubthalern ist auch bereits dem Herrn *Pons* ausgegablt worden."

I must confess that to me this announcement appears not only "incomplete," but scarcely worthy of credit. Herr Reissig is stated to have discovered another comet, which he calls a star, in the constellation Ophiuchus, on the 2nd of February, 1803, of which he gave four places in a letter to Bode, dated the 1st of July of that year ('Berliner Jahrbuch' for 1806, p. 266). These places are very difficult to reconcile with any cometary path, and Bode suspected errors in the calculations on which they were founded. It seems to me that the proper conclusion is that Reissig was an incompetent observer as well as calculator, and that his claim to have discovered the comet of 1801 twelve days before Pons cannot be trusted, and is certainly not sufficient to invalidate the claim of Pons to have been its first discoverer.

The point is of some interest, because, if my argument be correct, the comet in question is the first of the long series of cometary discoveries made by that astronomer. The last was that found by him at Florence on the 2nd of August, 1827. Pons died there on the 14th of October, 1831.

Yours faithfully,

Blackheath, 1886, Sept. 3.

W. T. LYNN.

P.S. (Sept. 8).—Since writing the above, I have noticed that the subject of the supposed comet of 1803 was discussed in the "Astronomical Column" in 'Nature' for 1876, August 10. An orbit is there computed (copied into 'Vade Mecum,' where the calculation is assigned by an intelligible mistake to "Lockyer") from the rough places stated to have been observed by Reissig. If the observations in question can be relied upon, which seems, under all the circumstances related, to be very doubtful, they would indicate that the comet was not (as Bode surmised from a hasty inspection) very distant from the Earth, but must at one time have approached exceedingly close to it. Upon the whole it seems that the alleged object can scarcely be reckoned amongst the comets, and that it is best not to include it in any list of cometary orbits.—W. T. L.

The Constellation Solitarius.

GENTLEMEN,—

It is well known that about 110 years ago Le Monnier proposed two new names of constellations which have not been generally accepted—Tarandus in the northern hemisphere, between Cassiopeia and Ursa Minor, and Solitarius in the southern, in the lower part of Libra bordering on Virgo. The name Tarandus speaks for itself; but what bird is represented by Solitarius? Bode enters the group on the maps in his 'Uranographia,' published in 1801, as "Turdus Solitarius"; Piazzi, however, adopting the nomenclature in his Star-Catalogue which appeared soon afterwards, refers to it under the single name Solitarius. In some modern works (amongst others the excellent 'Star Guide' of Mr. Latimer Clark and Mr. Herbert Sadler, which was noticed in your April number) it appears as Turdus Solitarius.

Now the bird usually known in French as "le Solitaire" is that extinct one of the pigeon tribe, allied to the Didus or Dodo, which formerly inhabited the island of Rodriguez, and to which modern ornithologists have assigned a distinct genus, calling it *Pezophaps solitarius*. It is evident, however, on reference to Le Monnier, that this was not the bird he had in view, though from his text alone one might think that it was. His paper describing the proposed constellation and giving a catalogue of twenty-two stars between the sixth and ninth magnitudes which are included in it, is in the 'Histoire de l'Académie,' vol. for 1776, p. 561. He there says, "La figure de la constellation du Solitaire (oiseau des Indes et des Philippines) a été préférée, en mémoire du voyage en l'ile Rodrique, m'ayant été fournie par MM. Pingré et Brisson, voyez le *tome* II de *l'Ornithologie*; cette constellation sera voisine du Corbeau et de l'Hydre sur nos planisphères et globes célestes." His reference to the voyage to Rodriguez naturally suggests the bird of which I have spoken, described by Leguat, in that unfortunate expedition which ended in his being conveyed to Java, whence he returned to Europe, and died in England in 1735, after publishing the account of his voyage in 1708. But the figure given by Le Monnier on the plate in the 'Mémoire' which accompanies his paper shows clearly that he was not intending to transport Legaut's "Solitaire" to the heavens. The bird there engraved really appears to be a sort of thrush; and the drawing is in fact a copy of that in Plate xxviii. fig. 1 of the second volume of Brisson's 'Ornithologie' referred to (as I mentioned above) by Le Monnier. It is to be remembered that when that work was published (1760) the binomial system of nomenclature introduced by Linnæus was not in general use. Brisson calls the bird "Le Solitaire des Philippines," or in Latin "Merula Solitaria Philippensis;" he describes it, but makes no reference to any voyage to Rodriguez, so that Le Monnier must have written in some confusion of thought. One species of thrush, often called *Turdus solitarius*, is found in the south of Europe. On the whole, those who desire to recognize the constellation had better, it seems to me, follow the example of Piazzi and call it simply "Solitarius."

Yours faithfully,

Blackheath, 1886, Sept. 18. W. T. Lynn.

NOTES.

Total Solar Eclipse, 1886, Aug. 29.—The expedition sent out to observe the total solar eclipse of August 29 arrived at Barbados on August 11, and found two gunboats, the 'Fantôme' and the 'Bullfrog,' waiting there to render them assistance. The instruments belonging to the Rev. S. J. Perry and Mr. Maunder were at once transferred to the 'Bullfrog,' and those belonging to the other members of the party to the 'Fantôme,' and both vessels proceeded at once to Grenada, the latter vessel having Mr. Lockyer and Prof. Thorpe on board. The other members of the expedition followed in the Royal Mail Steamship 'Eden,' and the entire party reassembled on the evening of Aug. 12 at the Government House, St. George, Grenada, where they had been invited by the Governor of the Windward Islands, for the purpose of discussing the question of the most suitable stations to be occupied. The discussion was resumed on the following morning, and it was decided that Capt. Darwin and Dr. Schuster, with Mr. Lawrance their assistant, should occupy Prickly Point, one of the promontories on the south coast of the island, that Prof. Thorpe should take up his station on Hog Island, about a couple of miles further to the east, that Prof. Tacchini and Mr. Turner should select a site in the neighbourhood of Grenville, the principal town on the east coast, and that Father Perry and Mr. Maunder should go to Carriacou, an island 18 miles to the N.E. of Grenada. Later on Mr. Lockyer decided to observe from Green Island, a small island just off the N.E. point of Grenada. The stations therefore extended along a line nearly 40 miles in length across the path of the shadow.

The fortnight which intervened before the eclipse was spent in the erection of huts and instruments, and in making other necessary preparations. In these the observers were very greatly helped by the assistance which Captains Archer and Masterman, the commanding officers of the two gunboats, and Captain Oldham, of H.M.S. 'Sparrowhawk,' so freely gave, the entire resources of the vessels being placed at the disposal of the expedition; the Governor, too, and the leading officials spared no pains to make the expedition a success, and the owners of property in the neighbourhood of the various stations received the observers in the most hospitable and generous manner.

The weather on the morning of the eclipse was somewhat unfavourable; the sky was generally overcast, and a heavy shower fell shortly before totality. The clouds broke, however, before the critical moment at Carriacou, and the entire phenomena were seen in a clear sky. At Boulogne, near Grenville, the last minute of totality was lost by cloud, at Hog Island the first 40 seconds; at Prickly Point the last 50 seconds were lost; whilst at Green Island, which had been generally expected to be the best station, nothing could be seen at all.

The following is a list of the stations with the instruments and observers at each, beginning at the south and proceeding northwards.

I. *Prickly Point.* Lat. 12° 0′ N., Long. 61° 46′ W.

Coronagraph: Capt. Darwin. Six plates exposed during totality and a large number before and after.

Prismatic camera: Capt. Darwin. One photograph.

Five-foot camera: Dr. Schuster. Four photographs.

Spectroscope with camera, slit tangential: Dr. Schuster. One photograph.

Spectroscope with camera, slit radial: Dr. Schuster. One photograph.

Disk: Capt. Maling, Colonial Secretary.

II. *Hog Island.* Lat. 12° 0′ N., Long. 61° 44′ W.

Photometer mounted on 6-inch equatoreal: Prof. Thorpe, with Mr. Lawrance at the galvanometer. Determinations of intensity of different districts of the corona.

Integrating photometer: Lieuts. Douglas and Bairnsfather, H.M.S. 'Fantôme.'

Disk: Capt. Archer.

Batteries and galvanometers: Mr. Webb and two torpedo-men.

III. *Boulogne, near Grenville.* Lat. 12° 9′ N., Long. 61° 38′ W.

Six-inch equatoreal with one or other of the following spectroscopes—a direct-vision spectroscope, a grating, and a Browning spectroscope of two prisms: Prof. Tacchini. The most careful comparison possible was made of the prominences seen in full sunshine and those seen during totality. The spectrum of the "flash" seen by Prof. Young was traced to a higher region than heretofore.

Six-inch equatoreal and grating spectroscope: Mr. Turner. Mr. Lockyer's Egyptian observations confirmed with tolerable certainty.

Four-inch equatoreal: No satisfactory observations of currents in the corona. (The completion of the other observation and cloud interfered with the work.)

Disk: Lieut. Smith, H.M.S. 'Sparrowhawk.'

IV. *Green Island.* Lat. 12° 14′ N., Long. 61° 35′ W.

Six-inch Henry equatoreal, giving an image of the Sun one inch in diameter: Mr. Lockyer, assisted by Mr. Wright, Chief of Police, and Mr. Elliot, Government Botanist.

Four-inch photoheliograph, giving an image of the Sun two inches in diameter: Capt. Oldham, H.M.S. 'Sparrowhawk,' Dr. Boyd, and Mr. Beresford, Clerk of the Council.

Disk: Capt. Hughes, Protector of Immigrants, and Mr. Belton, the owner of Green Island.

Timekeeper: The Governor of Grenada.

It is especially to be regretted that this powerful and well-trained party were denied any view of the eclipse. The result of their preliminary drills proved, however, that it is perfectly practicable to secure a series of no fewer than 16 photographs of the corona, two of them with long exposures, during an eclipse of 230 seconds duration.

V. *Hermitage, Carriacou.* Lat. 12° 27′ N., Long. 61° 29′ W.

Diffraction spectroscope on 5-inch equatoreal: Rev. S. J. Perry, Sub-Lieutenant Helbie, H.M.S. 'Sparrowhawk,' directing the position of the slit. 1474 K and a number of other short bright lines observed two minutes before totality. No trace of a carbon spectrum could be detected.

Five-foot camera: Mr. Maunder. Seven photographs, exposures ranging from 0·2 second to 40 seconds.

Spectroscope with camera, radial slit: Mr. Maunder. One photograph.

Spectroscope with camera, tangential slit: Mr. Maunder. One photograph.

Disks: Capt. Masterman and Mr. Osburn, Paymaster H.M.S. 'Bullfrog.'

VI. A sixth station was occupied by Mr. W. H. Pickering, from Boston, Mass., U.S.A. Mr. Pickering took up his position in Fort George, Lat. 12° 3′ N., Long. 61° 45′ W. He was favoured with a good view of the total phase and exposed a number of plates on the corona. His principal instrument was a photoheliograph of about 38 feet focal length, giving an image of the Sun 4 inches in diameter. Mr. Pickering also organized a series of observations of the shadow bands.

It is too early as yet to fully review the results of the expedition; the photographs, for instance, both of the corona and its spectrum will require much examination, indeed many are as yet still undeveloped. We may reasonably hope for much valuable information from these, though the comparative faintness of the corona as compared with former eclipses may possibly render some of the more lightly exposed plates useless. The photographs Capt. Darwin has taken will probably decide the question one way or the other as to the true character of the photographs obtained by Dr. Huggins' method of photographing the corona of the uneclipsed Sun. The various observers with disks after the method employed by Prof. Newcomb in the 1878 eclipse all agreed in representing the corona as essentially stellate in form, a number of rays having been detected radiating from the Sun in different directions, and not very dissimilar in length. The general appearance, therefore, was markedly different from that of the 1878 corona, in which two greatly elongated streamers on opposite sides of the Sun formed the most striking feature. The spectroscopic observations were on the whole highly successful. All observers agreed as to their inability to detect any trace of carbon flutings—a negative observation, it is true, but not the less important. Mr. Turner succeeded to some extent in confirming Mr. Lockyer's observations made in the Egyptian expedition of 1882 as to the length and order of appearance of a number of lines in the neighbourhood of F. Prof. Tacchini was more fortunate still. By a careful comparison between the prominences seen during totality and those seen by the spectroscopic method in full sunshine he arrived at the following conclusions:—1. That very fine prominences are seen during totality which are not visible by the spectroscopic method in full sunshine. 2. The prominences seen during totality alone are white, especially in their highest portions. 3. The luminous intensity of the white prominences is small, so that they are not visible to the naked eye unless their height exceeds that of the brightest part of the corona; whilst their summits can be seen with the naked eye if they attain a great height, as in this last eclipse. 4. All prominences show themselves larger and taller during a total eclipse than in full sunshine, and the upper portions are always white, if the prominence attains a certain height, viz. beyond a minute of arc. M. Tacchini also observed the spectrum of the "flash" first observed in the eclipse of 1870 by Prof. Young and Mr. Pye, but succeeded in tracing it to a far greater height than formerly, the bright lines becoming more visible as the illumination of the Earth's atmosphere was diminished when the dark Moon hid not the Sun only, but the brightest portions of the corona.

Dr. Huggins' Method of Photographing the Corona.—Directly the account of the result of Capt. Darwin's experiments reached England, Dr. Huggins addressed a letter on the subject to the 'Times.' He first reviewed the results of his earlier attempts to photograph the corona without an eclipse, pointing out that many of the plates presented appearances which those most competent to judge considered to be probably due to the corona, and that the plates taken in England about the time of the eclipse of May 6, 1883, not only resembled the photographs taken at Caroline Island in general appearance, but showed a remarkable rift, which was the main feature of the corona as seen during totality. Since the summer of 1883, the abnormally large amount of air glare had prevented successful experiments being made, and the plates taken by Mr. Ray Woods, in 1884, in Switzerland were inconclusive.

"Such," Dr. Huggins goes on to say, "was the state of things before the eclipse of August 29. The partial phases of this eclipse furnished conditions which would put the success of the method beyond doubt, if the plates showed the corona cut off partially by the Moon during its approach to and passage over the Sun. As the telegrams received from Grenada, and a telegram I have this day received from Dr. Gill at the Cape of Good Hope, state that this partial cutting off of the corona by the Moon is not shown upon the plates, I wish to be the first to make known this untoward result. I greatly regret that a method which seemed to promise so much new knowledge of the corona, which under ordinary circumstances of observation shows itself only during total eclipses, would seem to have failed. At the same time, I am not able to offer any sufficient explanation of the early favourable results to which I have referred briefly in the opening sentences of this letter."

Mr. Common, writing under date Sept. 13, replies to this letter in a more hopeful strain, and points out that "it is quite possible, and, indeed, probable, that this" (the failure to get a picture of the Moon projected on the corona) "is due entirely to the state of the sky, for against such unfavourable negative as this we have the positive evidence that the Moon has been seen so projected in various solar eclipses, and in one case it has been so photographed. This was by Liais, at Paranagua, in 1858, under conditions that were not, so far as concerns the processes employed, nearly so favourable as those now in use. This single piece of positive evidence, if correct, is of vital importance in showing that the present failure is probably due only to such temporary causes as have prevented Dr. Huggins getting lately such promising plates as those he obtained in 1883."

Mr. Common's suggestion is at least a plausible one, since the weather at Grenada during the total eclipse was by no means perfect, some 50 seconds having been entirely lost through cloud at Capt. Darwin's station, and it is possible that a careful examination of the Cape and Grenada plates may show that the images impressed upon them are not quite of the same character as those shown on Dr. Huggins' most promising negatives. It should also be borne in mind that the corona was particularly faint during the recent eclipse; so that though it must be admitted that the results obtained throw a certain amount of doubt on Dr. Huggins' photographs, they do not, so far as we at present know, actually *disprove* their coronal nature.

Time Reform in Japan.—In a letter to 'Nature' (Vol. xxxiv. p. 468), Mr. D. Kiruchi, of the Imperial University, Tokio, states that the following decree, relative to time-reckoning in Japan, was issued on July 12, 1886:—(1) The meridian passing through the centre of the transit-instrument at the Observatory of Greenwich shall be the initial meridian for longitude. (2) Longitude shall be counted from this initial meridian in two directions up to 180°, east longitude being + and west longitude —. (3) On and after the first day of the first month of the twenty-first year of Meiji (January 1, 1888), the time of the meridian of 135° E. shall be used as standard time throughout the Empire.

Publications of the Washburn Observatory.—In March 1884 Prof. Holden offered to observe the 303 fundamental stars for Schönfeld's southern extension of the 'Durchmusterung.' The work was begun May 2, 1884, and finished December 25, 1884, and the results have been published in Vol. iv. of the 'Publications of the Washburn Observatory.' In all 6444 observations were made with the Repsold meridian circle; each star of the 303 was completely observed six times, and the instrumental constants were

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

Edited by E. W. Maunder, F.R.A.S., A. M. W. Downing, M.A., F.R.A.S., and T. Lewis, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpool Astronomical Societies; Articles by various eminent Astronomers, English, American, and Continental; Correspondence on topics of interest connected with the Science; Notes on the progress of Astronomy; Reviews of astronomical publications; Ephemerides of comets, variable stars, Saturn's satellites, and for physical observations of the Sun, Jupiter, &c.; and all the usual astronomical information.

Amongst the contributors to 'The Observatory' in 1885 were Professors Asaph Hall, Holden, Hough, Pickering, Pritchard, and Young; Dr. Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs. Barnard, Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

"This journal is an indispensable complement to the 'Monthly Notices.'"—*Bulletin Astronomique* (organ of the Paris Observatory).

CONTENTS OF No. 115.

Page

Articles:—

Photographic Determinations of Stellar Positions. By B. A. Gould, For. Assoc. R.A.S. 321
Meteor Notes. By W. F. Denning, F.R.A.S. 326
Large Telescopes *v.* Small. By Prof. C. A. Young, Ph.D., For. Assoc. R.A.S. 328

Correspondence:—

δ Cygni. By Victor Nielsen, P. S. Yendell, and Rev. Jevon J. Muschamp Perry 329, 330
Comets and Meteors. By W. H. S. Monck, M.A., F.R.A.S. 331
Occultation of Venus by the Sun. By the Rev. S. J. Johnson, F.R.A.S. 332
Proper Motion of a faint Star. By Prof. J. G. Porter 332
Suspension of Mercury-trough.—New Variable. By R. L. J. Ellery, F.R.S. 333
Performance of a Telescope. By Dr. F. Terby 334
The Perseid Shower. By T. W. Backhouse, F.R.A.S. 335
Universal Time. By T. W. Backhouse, F.R.A.S. 335
Periodic Comets. By W. C. Evans, M.A., F.R.A.S. 336
Pons's first Cometary Discovery. By W. T. Lynn, B.A., F.R.A.S. 336
The Constellation Solitarius. By W. T. Lynn, B.A., F.R.A.S. 337

Notes:—

Total Solar Eclipse, 1886, Aug. 29.—Dr. Huggins' Method of Photographing the Corona.—Time Reform in Japan.—Publications of the Washburn Observatory.—New Comet.—Variable Stars.—Gould's 'Astronomical Journal.'—Editorial Notes 338-34

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 116. NOVEMBER. 1886.

Liverpool Astronomical Society.

The first meeting of the Sixth Session was held on October 11th. The chair was occupied by the Rev. T. E. Espin, B.A., F.R.A.S. (President).

Eighty-one members were elected and ten candidates were proposed. Of the total number, 15 were from Liverpool, 24 from other parts of England, 9 from Ireland, and 43 from North and South America. Mr. W. H. Davies (Secretary) announced the deaths of four members during the past year. A short account of their lives had been prepared and would be published in the 'Journal.'

The President complimented the Council on their able management. He thought the long list of members which the Secretary had just read was without a parallel in any scientific society in the world, and likely to prove by far the most important paper of the evening. (Laughter.) To the students of the educational branch he would especially address himself, and he thought he could promise they would never regret their choice of a science. Of all others, astronomy was the most fascinating, and the love of it only increased with its study. As an example of devotion, he instanced Sir W. Herschel, who once spent more than forty hours of uninterrupted work in putting the finishing touches on his large speculum, and could not be induced to leave it even for food. It had been said that night work was injurious; but he had never found it so, though last winter he spent many nights knee-deep in the snow. Perhaps this immunity was in some measure due to the clearness of the air, since no astronomer would think of uncovering his telescope in foggy or rainy weather. He had headed his address, "Stellar Variation: A Chapter in a World's History," and they would be prepared to hear that he regarded variation as a stage of development through which perhaps every star either has passed or must pass. Might not variation be due to stages of axial rotation? Let them suppose in the star's early history a central heat and external vapours in a cooler state: they had then a spectrum of the third type. Let the axial rotation go on increasing, and the temperature also, then there would be a struggle between the hotter and cooler vapours, and we should have an irregular variable like 19 Piscium. Passing to a time when the rotation had quickened, they could imagine the absorbing vapours more and more compressed in area; this would give a long-period variable with great variation in its light. Taking R Hydræ as an example, they would find its period in 1785, 500 days, but in 1825 it was only 461, and in 1870 it had decreased to 437: in other words, its rotation was now 60 days less. Let them suppose that a time would come when, by increased rotation and temperature, the vapour would no longer have power of cohesion, and would be thrown out irregularly all round the star. At this stage they might expect to find a spectrum merging from III. *a* into II., and the light irregularly variable. He forebore to speculate on the origin or the end of such a star, or whether it ever had been or would become a nebula, but these chapters in a star's history were full of interest. In variable stars they might read something of our Sun's history. In the geological record, had they any hints as to a past history of great variation? Those strata, each showing a higher period of development, were they impressions of contemporaneous solar development? Would our Sun ever lose these vapours of absorption, and stand out as a star of the first type like Sirius, with its present heat increased a hundredfold? How bright will it then be, and what will be the period of its rotation? Will animal or vegetable life exist under those conditions? Such questions must remain unanswered in our time, and we must be content to observe, to watch, and to record.

In a paper on the retardation of Encke's comet, Mr. W. H. S. Monck, M.A., F.R.A.S., accounted for its slower motion by its passing through systems of meteors, rather than by the generally accepted theory of a resisting gaseous medium. Wherever meteors existed, the motion of any celestial body must be retarded by their influence, because a large majority must be coming from an opposite direction. This would be understood if they considered that in walking along a tram-line they would meet with more cars than would catch up to them; not only so, but the momentum would be greater, as their own motion would, practically be added to it. The number of meteors flying about space was greater than most people imagined; it had been computed that the Earth receives the impact of several millions in the course of a single day. In the case of a solid body like the Earth, the shock would be too small to be appreciable; but with a light body like Encke's comet, the effect would be to seriously retard the motion. Collisions with meteors would also be more frequent nearer the Sun, at all events up to the distance that Encke's comet approached it. Astronomers had inferred the presence of a great mass of meteors inside the orbit of Mercury, as the only way of explaining certain irregularities in the motion of that planet: and, as both meteors and comets would then be near their perihelion, they would be moving with increased speed, so that the retarding effect would be greater.

Mr. W. F. Denning, F.R.A.S., pointed out that in July and August, when the Earth is further from the Sun, there are quite double the number of meteors that are visible in January and February. This alone would go far to negative Mr. Monck's theory that meteors were more crowded near the Sun. It should also be remembered that Encke's comet was not a coherent mass of matter, but a collection of very small bodies. The effects of its collision with meteor-streams would therefore be of a very different nature to that in which a solid planetary body like the Earth was concerned. A meteor-stream would probably pass completely through Encke's comet—itself but a highly-condensed group of meteors—without affecting its motion. There would be virtual, but not actual collision, except perhaps in the case of a very few individual atoms of the opposing systems. A solid body presenting a compact front would receive all the force of the impetus, but in the case of a comet and meteor-stream there would only be permeation.

The Secretary read a paper on "The Search for Vulcan," by Mr. T. W. Backhouse, F.R.A.S. It was of great importance that the existence of an intra-Mercurial planet should be determined, and a systematic watch ought to be kept during the period when, according to Leverrier's calculation, it was possible for Vulcan to be in transit across the Sun's face. This would entail very little extra trouble now that the Society had so many observers in both hemispheres, many of whom were constantly watching the Sun in the interest of other branches of astronomical research.

Mr. T. G. Elger, F.R.A.S., addressed some remarks especially to beginners. In many respects, he said, a study of the Moon presented advantages such as no other celestial body could claim. There we saw the actual surface of another world unobscured by clouds or exhalations, and could contemplate the marvellous details of its structure rather in the spirit of a physical geographer than of a telescopist. The beginner would soon see that the Moon had been nothing like so exhaustively studied as to leave nothing for small telescopes to do. In commencing this study they should first make themselves acquainted with the more obvious characteristics into which its surface is divided, and in this they would be much assisted by Webb's, Mellor's, or other convenient maps. As a rule they would find the majority of objects easier to observe when the Sun had just risen on them. At those times the surface was brought into strong relief by shadows, the significance of which they would soon learn to interpret.

Mr. K. J. Tarrant counselled beginners not be discouraged if they could not at once distinguish objects with small apertures. Now-a-days if a man wrote to say he had picked up such-and-such an object, or had split a close double star, somebody else would be sure to do so with a smaller aperture; indeed he sometimes wondered whether imagination had not a great deal to do with it. This kind of thing was very disheartening, and no doubt many a good telescope had been condemned on very insufficient grounds. Of course a great deal depended upon the air. As an example: there was one abnormally clear night last winter when the fifth and sixth stars of θ Oronis were quite easy objects: whereas on the next night, which was apparently quite as clear, they were not distinguishable.

Papers were read on "The Classification of Variable Stars," by Mr. J. E. Gore, and on "Cassini: A Lunar Crater," by M. C. M. Gaudibert. Other papers were received on "The Effect of Terrestrial Heat on the Moon," by Mr. W. H. S. Monck; on "Some Remarkable Sun-spots," by Miss E. Brown; on "The Masses and Distances of Binary Stars," by Mr. J. E. Gore; on "The Lunar Crater Mädler," by Mr. T. G. Elger; and on "Interesting Facts about Binary Systems," by Mr. K. J. Tarrant.

Arrangements were made to hold educational classes fortnightly, and Mr. J. S. Brown, 274 Upper Parliament Street, was appointed Secretary to the branch.

Meteor Notes.

On Sept. 20, during a 2½ hrs. watch, I counted 12 meteors, and on Sept. 22, in 4 hours, 32 were seen. On the latter night the chief shower was from 292° +71°, and I noted some additional meteors from it on Sept. 30. This radiant falls close to the best display seen here on Aug. 27–29, 1886, at 292° +70° ('Observatory,' Oct. p. 327); and it is doubtless identical with a position given by Heis for Sept. 22–Oct. 31 at 290° +72°, and with a shower I detected on Oct. 2–5, 1877, at 290° +70°.

On Sept. 22 this year I also noted a large meteor from a radiant at 63° +23°, which is confirmed by some additional observations obtained here in 1879 and 1884.

On Sept. 27 in 5 hours I counted 50 meteors, including a fine shower of bright, streak-leaving meteors, from 75° +15°. Several radiants cluster at this point in August and September, as follows:—

Epoch.	Radiant.	Observer.
1884, August 25	74° +15°	D.
1877, September 7–15 ..	73 +14	D.
1885, September 9	73 +14	D.
1871, September 22	75 +15	Tupman.

My recent observations prove this radiant is prolonged to Sept. 27. Amongst the other centres determined on Sept. 27 I may mention positions at 14° +12°, 115° +52°, and 87° +35°, as unusually well defined.

On Sept. 30 I found meteors very numerous, though dense masses of fog were coming up from the Bristol Channel and continuous watching was out of the question. I saw 31 meteors in 2½ hours; but the paths were very discursive and their radiant-points more numerous than active.

On Oct. 2, during an observation of 5½ hours, I reckoned 50 meteors. There was a fairly rich display of short, quick meteors, from a point near Capella, at 73° +41°. Several radiants near this star have been recognized in preceding years in the months of Sept. and Oct.:—

Epoch.	Radiant.	Observer.
1877, September 15–16..	72° +41°	D.
1879, September 21	76 +44	D.
1884, September 22	73 +45	D.
October	75 +45	Corder.
October 17–31 ..	75 +44	Heis.

I suspected it also on Sept. 12, 1885.

The other showers seen on Oct. 2, 1886, were 32° +19°, 98° +29°, 98° +43°, and 115° +80°. On Oct. 2, 1877, I discovered a display of several unusually brilliant meteors from 225° +52°; but there was no visible recurrence of it during the present year, though I looked for it very carefully.

The following is a list of several meteors recently registered here, and remarkable either for brightness or very slow motion:—

1886.	h m	Mag.	From	To	
Sept. 22...	10 26	♃	50° +20°	42° +18°	Slowish; streak.
27...	15 21	♃	16 +46	17½ +61	Slowish; train.
27...	16 33	♃	109 +63	144 +72	Very swift; streak.
30...	10 3	>1	22 +12½	54 +18	Very, very slow; yellow. Duration 7 sec.
Oct. 2...	16 22	3	77 +54½	112½ +35½	Very, very slow; train; dull. Duration 6 sec.

The meteor of Sept. 30 was very bright, and sailed along a course of 32° with abnormal slowness and with some curious fluctuations of light. The radiant was probably on the equator in R.A. 347°; and I have been expecting to hear of this object from the eastern parts of England, where it would be a more brilliant object.

As to the meteor of Oct. 2, that exhibited a very obvious disk, and as it slowly descended a number of flaky sparks were cast off. The body was singularly dull, considering its apparent size, as though its extremely slow movement through the air had barely enabled it to reach the temperature of incandescence.

Bristol, 1886, Oct. 6. W. F. Denning.

A Method of Collimating Newtonian Reflectors.

Preliminary Arrangements.—The tube of the reflector is perforated by a hole about 14 millim. aperture exactly opposite the

CORRESPONDENCE.

To the Editors of 'The Observatory.'

δ *Cygni.*

MESSIEURS,—

Je me permets de prendre part encore à l'intéressant échange d'observations dont δ Cygni est l'objet dans votre Revue. Sans aucun doute la *grande difficulté* que présente cette double provient de la différence d'éclat des deux composantes et de l'antagonisme des conditions favorables de visibilité pour chacune d'elles: un ciel éclairé facilite l'observation de la grande étoile *et de son entourage* en supprimant le rayonnement et les anneaux; mais trop de clarté nuit à la visibilité de la petite étoile, qui n'est que de 8^e grandeur. Pendant le crépuscule, ou vers le moment du coucher du soleil, il se présente sans doute un intervalle de temps pendant lequel le ciel est suffisamment sombre pour permettre de voir le petit compagnon, et suffisamment clair pour supprimer le rayonnement et les anneaux capables de le masquer. Il est naturel qu'avant et après ces moments le compagnon soit très difficilement visible. Toute cause d'éclairement du ciel dans les proportions voulues permettra de voir le compagnon avec plus de facilité, et je vous écris spécialement pour dire que l'éclairement qui m'a semblé le plus favorable est celui que produit la lune. Voici quelques exemples: le 11 septembre dernier, vers 9^h 30^m du soir, pendant le clair de lune, je voyais parfaitement le compagnon avec le grossissement de 650 fois de mon huit pouces de Grubb; δ Cygni était près du zénith.

Le 12 septembre, entre 8 et 9 heures du soir, dans des conditions analogues, je ne réussis pas à voir le compagnon.

Le 14 septembre, entre 8^h et 9^h 30^m, pendant le clair de lune et au zénith, je vois le compagnon à l'aide des grossissements de 450 et de 650, *aussi bien à peu près que celui de ζ Herculis*, qui est du même type, mais beaucoup plus facile.

Le 5 octobre, entre 8^h et 10^h, encore en présence de la lune, le compagnon apparaît même avec le grossissement de 250 fois et d'une façon si remarquable que le couple se présente, toute proportion gardée, comme une miniature d'Antares accompagné de son satellite.

Avec le grossissement de 450 fois le compagnon se voit admirablement.

Avec le grossissement de 650 fois, je ne le distingue plus aussi bien, probablement parce que le ciel s'obscurcissait à cette heure plus avancée, à l'approche du coucher de la lune.

Je n'entrerai pas dans le détail des observations de nébuleuses que j'ai faites avec mon équatorial, qui résout d'une façon complète la nébuleuse d'Hercule et montre le *Dumb-bell* avec toutes ses particularités: ellipse générale dans laquelle se détache le *battant de cloche*; j'insisterai cependant sur le fait que ce battant de cloche

m'apparait *tout parsemé d'une infinité de petites étoiles* brillant comme de petites étincelles.

J'espère que MM. Young et Denning voudront bien lire ma lettre insérée dans le No. 114 de l'*Observatory*; ils y trouveront l'histoire complète des dessins de Mars dont ils se sont occupés.

Votre bien dévoué,

Louvain, le 7 octobre, 1886.

DR. F. TERBY.

GENTLEMEN,—

I have read with great pleasure the letters of your correspondents on the subject of this star. The strangeness of the case is the great diversity of opinion and experience they reveal. Dr. Copeland could only detect the companion on an occasion cited in his letter "once in every four or five minutes." M. Nielsen writes that it is "well seen." The latter observes with $5\frac{1}{3}$ in., the former with 15 in.

When I last tried, but failed, to detect the companion, it was in bright twilight, and with a well-adjusted and excellent instrument. As an example of its performance, I have measured ϵ Arietis on two different nights—one night six double measures, the other night three, with a difference between the nights' results of only $0''\cdot08$, using a parallel-wire micrometer.

I think much may be explained by the varying capacity of the eye in different observers, and in the same observer at different times. An eye defining well, but not easily dazzled, would obviously have a better chance with δ Cygni, while such an eye would not so easily detect minute points of light on a dark ground. The eye is very easily alterable, varying with use, fatigue, and general nervous power, to an extent which must always be taken into account. I have seen the companion to δ Cygni in less favourable atmospheric conditions than those in which I have failed. The instrument was the same, and, if anything, in better order, when I did not succeed. Either the star must have varied, or some curious atmospheric state prevailed, or the eye been more easily dazzled by the bright primary; most probably the last was the case. I have to thank cordially those who have given so much valuable information. The whole subject is one which seems to me worthy of investigation.

Yours faithfully,

Barrhead, Scotland,
1886, October 16.

EDWARD BRUCE KIRK.

Halley and the Total Eclipse of 1715.

GENTLEMEN,—

The last total eclipse of the Sun, as most of your readers are aware, which was visible in and near London, was that of the 22nd of April, O.S. 1715, previous to which none had occurred since 1140. It seems to me that it is worth while to call attention to the careful series of observations of the eclipse of 1715 which were corona-like markings. Successful results have also been obtained on September 8, 11, 13, and 14.

In *all* the photographs taken during September the coronal rays are higher near the N., E., S., and W. limbs of the Sun. The general form of the corona is therefore that of a cross. Minor changes occur, however, from time to time.

Sincerely yours,
T. S. H. Shearmen.

Brantford, Canada,
1886, September 30.

Lalande 10063.

Gentlemen,—

Ll 10063 may be new as a variable, but as a double star it is the well-known pair H 3750. It is Leporis 28; and was observed by Argelander with the Bonn circle on Jan. 14, 1853, when its magnitude was rated 6·0 (B. B. vi. p. 341). Houzeau rates it 5½ mag., 1875·09; Burnham 6·0 mag., 1879·131; O. Stone and Howe 5·0 mag., 1879·108. The pair measured by Prof. Stone in Cincinnati Obs. vi. seems to have been H 3752, P. v. 70 Leporis. H 3750 and 3752 are singularly alike in magnitudes and distances, the angles differing by just 180°. The angle of H 3750 given by Mr. Ellery on page 334 is 180° in error.

Yours faithfully,
Herbert Sadler.

Clapham, 1886, Oct. 15.

Telescopic Meteors and the Height of the Atmosphere.

Gentlemen,—

The approach of the Leonids and Andromedes leads me to suggest that some of our good telescopes should be turned on the neighbourhood of the radiant-points of these meteors during the critical nights. It is well known that many meteors are visible in the telescope which escape the naked eye; but it does not seem to have been ascertained whether this results from their smaller size, their greater distance, or both. Telescopic meteors, so far as I am aware, appear to move more slowly than those visible to the naked eye. The most natural explanation of this would be increased distance; for as larger meteors penetrate farther into the atmosphere before dissipation, and thereby enter denser regions, their motion is, on the whole, probably as much retarded by atmospheric resistance as that of the smaller ones. But if increased distance is the true explanation, we shall probably have to add to our present estimates of the height of the atmosphere. The reason why we do not see (with the naked eye) meteors at heights much above 100 miles may be the faint luminosity and greater distance of those which are vaporized in more elevated regions. The telescope may here come to our assistance. It would also be desirable to ascertain whether the course of a meteor visible to the naked eye could be traced farther back towards the radiant-point by the aid of the telescope. Two observers at the same station, one using the naked eye and the other the telescope, might throw some light on this question. It would also be interesting to examine a meteor-train with a good telescope, and to investigate by the same means the appearances produced at the point of dissipation. If a low magnifying-power was used and the shower was at all a rich one, several meteors ought to come within telescopic range during the night. I remain, truly yours,

W. H. S. Monck.

6 Gloddaeth Crescent, Llandudno,
1886, Oct. 22.

NOTES.

The Binary Star OΣ 234 *.—Mr. J. E. Gore has computed elements for this difficult and close binary (mags. 7 and 7·4), fixing the period at 63·45 years, the periastron passage for 1881·15, and the eccentricity at 0·3629. These elements represent the observations fairly well from 1844 to 1853 and from 1870 to 1880; but in the years 1858 to 1866 the discordances are considerable. Mr. Gore states that this orbit must be considered as only provisional.

The Satellites of Saturn †.—In a paper, entitled "Comparison of the Observations of the Five Inner Satellites of Saturn made at Toulouse in 1876 and 1877," Prof. Asaph Hall announces that he has now finished the reduction and discussion of the observations of Titan and of the five inner satellites of Saturn made at Washington since the mounting of the 26-inch refractor in 1873, and that this work is now ready for printing. The average probable error of a single observation for the position of a satellite is ±0″·27. A remarkable result of the discussion is that the Washington observations of the five inner satellites can be satisfied within the limits of their probable errors by circular orbits. It was hoped that the Washington observations would determine the positions of the lines of apsides with such accuracy that the motions of these lines would become known, and that a new determination of the mass of the ring and of the figure of the planet might thus be obtained, by comparing the elements of the inner satellites with those of Titan. Unfortunately the resulting circular orbits for the inner satellites make the position of a line of apsides indeterminate, and for the present the mass of the ring remains unknown.

On account of the difficulty of making good micrometrical measurements of the inner satellites of Saturn, astronomers have revived the old method of observing their conjunctions with the

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* Astron. Nachrichten, No. 2743.

† Ibid.

ends of the ring, or with some other marked features of the Saturnian system. In order to see how accurate the old method of observing may be, and at the same time to test the elements deduced by him, Prof. Hall has compared the observations made at Toulouse in 1876 and 1877 with these elements, and concludes that observations of these satellites with filar micrometers are among the best we have; and since they are definite measurements and are made in very different positions, a result deduced from such observations is more likely to be free from constant errors. Prof. Hall is, however, inclined to think that a heliometer must be one of the best instruments for dealing with measurements from such objects as Saturn and Jupiter; that is, assuming that the objective could be enlarged, otherwise its light power is too small for the inner satellites of Saturn.

THE CONTINENTAL OBSERVATORIES.—In the following short notices we briefly indicate the kind of work carried on in a few Continental Observatories during the year 1885:—

Berlin.—The work at this observatory was of the usual character. A large number of observations were made with the Transit Circle, the work being chiefly confined to obtaining positions of "comparison stars," small planets, comets, stars occulted by the Moon in the total eclipse of 1884, Oct. 4, and stars whose occultations by the Moon have been observed at Berlin, and numerous other stars. The 9-inch refractor was employed principally on small planets and comets. Herr Fœrster is the director.

Bonn.—This observatory is under the direction of Dr. Schönfeld. The work has been chiefly on "zone stars" and "comparison stars" with the transit circle, observations of comets, Nova Andromedæ and Nova Orionis.

Dresden.—This well-appointed observatory is the property of Baron von Engelhardt. Good positions of the following comets were obtained with the 12-inch equatoreal:—1884 III. (Wolf), 1885 I. (Encke), 1885 (Barnard), 1885 (Brooks 1), 1885 (Brooks 2), 1886 (Fabry), 1886 (Barnard); besides a number of positions of nebulæ, measures of double stars, occultations, and phenomena of Jupiter's satellites, observations of Nova Andromedæ and Nova Orionis. The meteor-shower of Nov. 27 was observed here.

Geneva.—At this observatory great attention has been paid to the testing and rating of chronometers and watches. M. Kammermann has made some good observations of comets, and has employed the 10-inch equatoreal in observations of the new stars in Andromeda and Orion. The meteor-stream of Nov. 27 was carefully observed.

Lund.—This observatory is under Dr. Möller. The observer, Dr. Dunér, is principally employed with spectroscopic work and observations of variable stars. Bad weather greatly interrupted the work in 1885, yet 147 observations of the spectra of red stars were obtained, and on three evenings estimations of the wave-lengths of the bands in R Andromedæ were made. The spectra of Nova Andromedæ and Nova Orionis were observed frequently. A few doub lestars were measured.

Milan.—Under the direction of Prof. Schiaparelli. During the year 230 measures of double stars were made, besides numerous observations of comets. The meteor-stream of Nov. 27 was well observed here.

Munich.—Prof. Seeliger has been unable to properly prosecute his researches on the parallax of stars on account of the unfavourable weather. Measurements of the system of Saturn were made. Numerous transit observations were made. The usual magnetic and meteorological observations were carried on.

Zurich.—Herr Wolf was still engaged in observations of Sun-spots. The Sun was free from spots on ten days during the year. He places the last maximum at 1883·9.

Prague.—At this observatory Prof. Safarik has been engaged in observations of variable stars, and in noticing variations of light in Ceres, Pallas, Juno, and Vesta. The November meteors were well observed.

The Pulkowa Catalogue of 3542 Stars for 1855.—This Catalogue (forming part of Vol. viii. of the 'Observations de Poulkova') contains the mean places of 3542 stars observed with the Pulkowa meridian circle during the years 1840–1869. It includes all the Bradley stars (with the exception of the Pulkowa Fundamental Stars) situated between the North Pole and the parallel of 15° south declination, as well as the comparatively small number of remaining stars, to the sixth magnitude inclusive, given in the 'Uranometria Nova' as occurring in the same part of the sky. In addition to these the places of some other fainter stars are also given in the Catalogue. The Fundamental Stars have not been included in the Catalogue, because the positions of the other stars as here given depend on the places of the former as determined by the transit-instrument and vertical circle. And as the definitive positions of the present Catalogue depend on two Catalogues of Fundamental Stars, viz. those for 1845 and 1865, it appears that the system of the Catalogue for the epoch 1855·0 will be practically identical with the mean of the two Catalogues above mentioned. In the great majority of cases the number of observations on which the place depends is four—that, is one observation in each of four different positions of the instrument. Proper motion, wherever possible, has been taken account of, the values taken from Volume iii. of Auwers' re-reduction of Bradley having been available. For other stars M. Struve has used the proper motions given in Bonn Observations, Vol. vii., and in some few instances has determined values of the proper motion for the purposes of this Catalogue. We have presented to us here what is undoubtedly a most valuable and accurate Star Catalogue; but we are impelled to ask, why was the publication delayed so long? Surely a Catalogue for the epoch 1855 deduced from observations made 1840–1869 might have been published fifteen years ago, and it would have been five times as useful as it is now.

A new Observatory in La Plata.—We are glad to learn that the Government of La Plata are fitting out an Observatory in the Province of Buenos Aires. If supplied as liberally with good workers as with instruments we may expect soon to have some good work done here. Among the numerous instruments are a telescope (reflector) 31·5 inches diameter, an equatoreal coudé 17 inches aperture, an 8-inch transit, an altazimuth, an apparatus for celestial photography, a large Thollon spectroscope 9·8-inch objective, numerous geodetic instruments, including three portable transits, a set of magnetic instruments, and finally fourteen collections of meteorological instruments, to be distributed over the district. The optical portion of these instruments is to be constructed by MM. Henry of Paris. A time-service is to be instituted. The observatory is to be under the direction of M. Beuf, late an officer in the French navy. It would seem that a large amount of geodetic work is to be done, including the measurement of an arc of a meridian, for which the immense plains of Chaco and Patagonia are extremely favourable.

The Motion of Hyperion *.—Mons. F. Tisserand, in a paper entitled "Sur un cas remarquable du problème des perturbations," considers the case of two planets moving round the Sun, or of two satellites moving round their primary in orbits but little inclined to each other, and shows that if the mean motions of the planets or satellites are very nearly commensurable, the remarkable consequence follows that if the motion of one of the planets or satellites, as the case may be, were originally circular and uniform, the perturbations caused by the other would have for their principal effect to transform this motion into motion in a Keplerian ellipse with a uniform rotation of the major axis. Applying this to the case of Hyperion perturbed by Titan, which has been investigated by Profs. Hall and Newcomb ('Observatory,' Vol. viii. p. 92), and in which there is one of the nearest approaches to commensurability of mean motion to be found in the solar system, M. Tisserand finds that his results agree closely with the facts of observation, the computed rate of retrograde motion of the perisaturnium of Hyperion being 18°·8 per annum, whilst the observed quantity is 20°, and that his value of the mass of Titan ($\frac{1}{10750}$) differs little from that obtained by Newcomb, viz. $\frac{1}{11000}$.

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* Comptes Rendus, Tome ciii. No. 9.

Bevis's Star Atlas.—There is a reference to this work in the 'Dictionary of National Biography' (Vol. iv. p. 451) which, there seems reason to think, is at least partially in error. The reference in question reads as follows:—"The work was all but ready for the press when, in 1750, John Neale, the publisher, became bankrupt; the plates, already completely engraved, were sequestered by the Court of Chancery, as it proved, irrevocably; and Bevis's heavy toils remained without fruit." The loss does not appear to have been quite irrevocable, since the libraries of the Royal Astronomical Society and of Greenwich Observatory each possess a copy, in very good condition, but without the printed explanations and the star catalogue, which the above-quoted article states to have accompanied the plates. The plates are fifty-one in number, viz. the forty-eight constellations of Ptolemy, a map of the southern constellations outside the limits of these, and the old forty-eight constellations arranged in two hemispheres. Each plate is dedicated to some distinguished person or institution, and bears the appropriate coat-of-arms. Pegasus is dedicated to Bradley, then Astronomer Royal, the two Triangles (most appropriately) to Bliss, Savilian Professor of Geometry, and Perseus to Martin Folkes, then President of the Royal Society. This last plate fixes the date of the work within the decade 1741–51; it bears no titlepage nor direct indication of date or authorship. The entire work was probably dedicated to Frederic, Prince of Wales, since the frontispiece shows Urania, introduced by Britannia, presenting the volume to him with a respectful air. This plan of dedicating each constellation to some particular patron had its scientific drawbacks, since it necessitated changing the scale from plate to plate, that the Arrow or Equuleus might make as brave a show as Ursa Major or Virgo. Beside the 48 ancient constellations which have thus each a plate to themselves, some thirty others are shown incidentally. These are the constellations introduced by Tycho, Bayer, Flamsteed, and Hevelius. Coma Berenices is represented in one instance by the well-known inverted Sheaf, and a small constellation, consisting of a bow and arrow, is introduced between Aquarius, Equuleus, and Delphinus. This appears to be Bevis's own origination. The plates are exceedingly well drawn, and must have entailed immense labour. The "Pilgrim," Tycho's star of 1572, is represented in the map of Cassiopeia by an immense star nearly two degrees in diameter.

An apparently undeserved slur has been cast upon Bevis's reputation in the 'Nouvelle Biographie Générale,' in which it is stated that he would have succeeded Bradley as Astronomer Royal had he been less addicted to the pleasures of the table. Mr. Lynn has pointed out ('Notes and Queries,' 7th series, ii. p. 245) that it was after Bliss's death, not Bradley's, that Bevis became a candidate for the post, and that, as he was then nearly 70 years of age, the preference given to Maskelyne can be readily understood without recourse to an imputation on Bevis's character, for which there appears to be no warrant. Bliss, as is well known, was latterly so closely associated with Bradley in his work, that he was his natural successor.

The Second Armagh Catalogue of Stars[*].—After the completion of the observations of Bradley's stars, the results of which were embodied in the catalogue commonly known as the 'Armagh Catalogue,' Dr. Robinson formed the plan of re-observing a number of stars occurring in Baily's catalogue from 'Lalande's Histoire Céleste.' The observations were commenced in 1859, but the 3¾-inch object-glasses of the transit instrument and the mural circle being considered too small for the work, the observing was stopped at the end of 1860, and the mural circle altered (by the liberality of Lord J. G. Beresford) into a transit circle with 7-inch object-glass. The observations were resumed in the spring of 1863 and continued with more or less regularity until the last were made in December 1883. Dr. Dreyer, on his appointment as Dr. Robinson's successor in 1882, considered it desirable to have the Armagh observations published with as little delay as possible, and the result of his labours is the publication of the second Armagh Catalogue, containing the places of 3300 stars for the epoch 1875, deduced from the observations made during the years 1859 to 1883. It is to be remarked that the results published by Dr. Robinson in 1879, in the 'Transactions of the Royal Dublin Society,' forming a catalogue of 1000 stars, are embodied in the present work, so that it and the catalogue of 1859 contain a complete record of the meridian observing at Armagh since 1827. This is no doubt a very satisfactory state of things, but considering the change in the instruments made in 1862–63 we venture to think that it would have been better to have discarded the observations made prior to that date, and to have confined the catalogue before us to the results of the observations made with one instrument under a uniform system.

The R.A.'s of this Catalogue (observed chronographically) depend on the standard stars of the 'Nautical Almanac.' The N.P.D.'s depend on the nadir observations, the adopted latitude being 54° 21′ 12″·70. The division errors of the circle were taken from a table drawn up by Dr. Robinson many years ago. The refractions used are also Dr. Robinson's ('Transactions Royal Irish Academy,' vol. xix.), which within the limits of this catalogue (Z.D. 83°) may be considered identical with Bessel's. The horizontal flexure was found in 1864 to be =0″·11; no correction for flexure has been applied. In reducing the observed places to the adopted epoch, proper motion was never taken into account. The precessions have been computed from Struve's constants. For each star in the catalogue is given (in addition to its position) Lalande's No., the mean epoch of observation, the number of observations, the annual precession but not its secular variation (a regrettable omission), as well as very complete references to the principal modern star catalogues.

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[*] Second Armagh Catalogue of 3300 Stars for the Epoch 1875. Alex. Thom & Co.: Dublin. 1886. 8vo.

From 400 observations made with the improved mural circle, of 80 stars between 30° and 100° N.P.D., Dr. Dreyer finds the probable error of one observation in R.A. and N.P.D. to be respectively $\pm 0^{\mathrm{s}}{\cdot}081$ and $\pm 0''{\cdot}85$, the single errors in R.A. having been multiplied by $\cos \delta$. For determination of the systematic errors the Armagh Catalogue has been compared with the Glasgow Catalogue of 6415 stars, not only because it was deduced from observations made nearly at the same time as the former (1860–81) and depended in R.A. on the same standard stars (the 'Nautical Almanac'), but also because it has already been rigorously compared by Auwers with his fundamental catalogue. From this comparison it appears that the N.P.D.'s of the Armagh and Glasgow Catalogues (which are quite independent of each other, in both cases being referred to the nadir) are in fair agreement, as are also those of the former with the fundamental catalogue. But in R.A. there are considerable discordances depending both on R.A. and on N.P.D., found by comparing the Armagh Catalogue both with Glasgow and with Auwers. With regard to the former it appears probable that an error in determination of azimuth may have been introduced, from the circumstance that the meridian mark, by which the azimuth of the Armagh instrument has been determined, is situated to the north of the observatory, and possibly the azimuth found by looking northwards was not strictly applicable south of the zenith. Dr. Dreyer thinks that the discordances in R.A. depending on N.P.D. probably arise from defects in the pivots or in the collimation of the Armagh instrument. He is inclined to think that the N.P.D.'s of this catalogue are on the whole much more satisfactory than the R.A.'s.

It only remains to say that the expenses of printing the catalogue were defrayed by a grant from the fund for the promotion of scientific research, administered by the Government Grant Committee, and that the work is very clearly printed and forms an exceedingly neat and handy volume. It is likely to prove a valuable addition to our stock of star catalogues.

PHOTOGRAPHS OF STELLAR SPECTRA EXHIBITING BRIGHT LINES [*].—Prof. Pickering states, in this communication, that among the photographic observations which have been undertaken at the Harvard College Observatory, as a memorial to the late Prof. Henry Draper, are included a series of photographs of the spectra of all moderately bright stars visible in the latitude of the Observatory. A recent photograph of the region in Cygnus, previously known to contain four spectra exhibiting bright lines, has served to bring to our knowledge four other spectra of the same kind. One of these is that of the comparatively bright star P Cygni, in which bright lines,

[*] 'Nature,' Vol. xxxiv. p. 439.

apparently due to hydrogen, are distinctly visible. This phenomenon recalls the circumstances of the outburst of light in the star T Coronæ, especially when the former history of P Cygni is considered (see Mr. Lynn's letter, 'Observatory,' Vol. ix. p. 314). It has recently been repeatedly observed at the Harvard College Observatory with the meridian photometer, and does not appear to be undergoing any variation at present.

Another of the stars shown by the photograph to have bright lines is DM + 37°·3821 *, where the lines are unmistakably evident, and can readily be seen by direct observation with the prism. The star has been overlooked, however, in several previous examinations of the region, which illustrates the value of photography in the detection of objects of this kind.

The other two stars first shown by the photograph to have spectra containing bright lines are relatively inconspicuous. The following list contains the designations, according to the 'Durchmusterung,' of all eight stars, the first four being those previously known:—35°·4001, 35°·4013, 36°·3956, 36°·3987, 37°·3821, 38°·4010, 37°·3871, 35°·3952 or 3953. Of these, 37°·3871 is P Cygni, and 37°·3821, as above stated, is the star in the spectrum of which the bright lines are most distinct.

OBSERVATION DES CANAUX DE MARS FAITE À L'OBSERVATOIRE DE NICE †.—M. Perrotin describes the configuration of the planet as observed in the Henry equatoreal of 15 inches aperture, with powers from 450 to 560. The observations were commenced at the end of March 1886, and continued, as frequently as circumstances permitted, until the middle of June. M. Perrotin notes the unfavourable conditions under which the planet was viewed, the apparent diameter at the date of opposition (March 6) being only 14″. He says, "On April 15 I distinguished one of the canals situated W. of the Kaiser Sea (Syrtis Major of Schiaparelli's chart), and placing it in communication with the straits of Herschel. M. Thollon saw it immediately after." Subsequently to this date the Nice observers succeeded in glimpsing a number of canals, exhibiting much the same outlines as those attributed to them by the director of the Milan Observatory. They appear to constitute in the equatoreal region of the planet a network of lines running in various directions, and projecting themselves upon the brilliant ground of the disk, as greyish lines of colour more or less intense. "Compared to the thickness of the spider-lines of the micrometer, the finest of these lines appear to have a width which corresponds to an arc of 2° or 3° on the surface of Mars. Certain of them measure

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* In 'Nature,' Vol. xxxiv. p. 570, Prof. Pickering points out that he has overlooked the fact that the spectrum of this star was observed by Dr. Copeland on September 22, 1884, and found to contain bright lines. 'Monthly Notices,' Vol. xlv. p. 91.

† 'Bulletin Astronomique,' July 1886.

from 50° to 60° of long., while several are double and composed of strictly parallel lines."

The Nice observers remark that some alterations of aspect were observed in the configuration of the features near the Kaiser Sea. On May 21 the region of this sea stretching from 10° to 55° of longitude was hidden by a luminous veil of the colour of the continents, but less bright and softer. Clouds or mists seemed disposed in regular parallel bands, rising on the planet from N.W. to S.E. At certain times these clouds became transparent, exposing to view between them the outlines of the lengthening of the Kaiser Sea. On May 22 they were more uniformly distributed than on the previous evening. Rapid variations in this luminous appearance caused certain regions of the seas to be alternately visible and invisible. On May 25 M. Perrotin observed the isthmus forming the lengthening of the Kaiser Sea beyond its junction with Nilus (Schiaparelli) towards long. 300°, lat. 32° N., which had remained hidden until this date. On the same night a very pronounced obscuration of the continents was noticed in the immediate vicinity of the Kaiser Sea. During these singular changes the S. part of the Kaiser Sea, which had not been affected by the clouds, became darker and presented a bluish-green tint.

M. Perrotin suggests that these phenomena were really produced by clouds or mists circulating in the atmosphere of Mars, and concludes that they are, in such case, the act of an element belonging to the atmosphere, or to the surface of the planet, susceptible of motion and modification in a relatively short time. At a little distance from the white spot at the N. pole, the Nice observers noticed, between long. 200° and 280°, two or three brilliant points, similar to those which were drawn by Mr. Green at Madeira in 1877 around the S. polar spot. In summarizing his results, M. Perrotin says they afford a striking confirmation of the discoveries of Schiaparelli on the remarkable physical appearance of this planet.

THE EDINBURGH STAR CATALOGUE *.—The present volume has been an unfortunate one. The first four hours of the catalogue were published in 1877, and the remaining twenty have had to wait nine years longer before the Government would sanction the cost of their printing. And to say the truth, the wonder is less that that sanction has been withheld so long than that it has been granted now; for, in our view at least, the very scheme and plan of the entire work is a mistake, and has involved much needless expense, a circumstance the more regrettable as the Edinburgh Observatory has long stood in need of increased funds.

To begin with, the very title is a misnomer. The present

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* 'Astronomical Observations made at the Royal Observatory, Edinburgh.' Being Vol. xv., for 1878 to 1886, containing only the remainder of the Star Catalogue Discussion and Ephemeris, for 1830 to 1890, of which the first four hours appeared in Vol. xiv. By C. Piazzi Smyth, F.R.S.E., F.R.A.S., F.R.S.S.A., &c. Published by Order of Her Majesty's Government. Edinburgh: Printed by Neill and Co. 1886. 1675 pp.

volume and its nine-year old predecessor are labelled 'Edinburgh Astronomical Observations,' Vols. xiv. and xv., whereas the Edinburgh observations are merely incidental. The salient feature of the work is the republication of B.A.C. star-places to the number of 3890, and their reduction to the epochs 1830, 1870, 1880, and 1890. It is true that these stars are chosen because they had been observed at Edinburgh; but since these tabular places are compared, not merely with Edinburgh observations but with catalogues from many different observatories, there seems no very valid reason why the work should have been confined to these particular stars. There seems no reason at all why the B.A.C. places have been reduced to 1880 and 1890, as there are no observations given near those epochs; indeed, the Edinburgh observations range from 1833 to 1872, a circumstance scarcely indicated by the dates on the back of the book, "1877–1886." Yet again, the Edinburgh observations are neither systematically given singly, nor properly combined so as to give a mean place for some selected epoch. Of course the idea has been to examine and correct the places, and especially the proper motions, of the British Association Catalogue; but this could have been just as well done in brief notes to stars for which error was suspected, and one half or two thirds of the mass of figures here given would have been saved. The information given in the notes also is often ill-chosen. For the distances and position-angles of double stars, the 'Bedford Cycle' is usually drawn upon. Perhaps this is excusable; but the most recent and most accurate observations were what were really required. But having followed the 'Cycle' where, from the lapse of time, apart from all other considerations, it was undesirable to do so, why was it departed from where it would have been a safe guide, viz. in the interpretation of the Arabic names, to follow such a known Will-o'-the-Wisp as "Mazzaroth?" Actually, Miss Rolleston's self-invented name for α Delphini—"Scalooin"—is gravely inserted, with her elaborate Arabic and Hebrew etymologies for it, and this although it has been well known for nearly twenty years that the names for α and β Delphini are simply "Nicolaus Venator," the latinized form of Niccolo Cacciatore, read the reverse way, and that they date back only to Piazzi!

We have recently received two really valuable works from Prof. Smyth, and we should have cordially welcomed from him either a sober, straightforward publication of observations or, what would have been still better, a star catalogue carefully prepared from the observations made at Edinburgh. But the work before us is, in our opinion at least, a mistaken one, and has involved no slight waste of labour and money.

ASTRONOMY AT THE AMERICAN ASSOCIATION *.—Many important papers were presented in the Section of Mathematics and Astronomy at the recent meeting of the American Association for the

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* Science, Vol. viii. No. 187.

Advancement of Science. Prof. Rogers presented two papers—one on the best form of Chronograph, and the other, with Miss Anna Winlock, on the limitations in the use of Taylor's theorem for the computation of the precessions of close polar stars. Prof. Doolittle presented a paper on a supposed change in the latitude of the Sayre Observatory. Two zenith-telescope determinations of the latitude, with an interval of nine years between them, from the same pairs of stars, with about the same number of observations, the two pieces of work being done with the same instrument, by the same observer, and as nearly as possible under exactly the same conditions, give a difference of latitude of 0″·393. Dr. Gould read a paper on photographic determinations of stellar position ('Observatory,' Vol. ix. p. 321). Mr. E. F. Sawyer communicated a paper containing an account of a new catalogue of the magnitudes of Southern Stars, *i. e.* those between the equator and −30° Dec. Dr. Elkin gave the results of a comparison of the places of the Pleiades as determined by the Königsberg and Yale College heliometers. The results given were provisional only, but they show unquestioned change of position with reference to η Tauri since 1840. Prof. Abbe presented a paper pointing out that as the force of gravity varies from the equator to the poles, 30 inches of mercury in the barometer indicates a less gaseous pressure, and consequently less density of the atmosphere at the equator than 30 inches at the poles, and hence a correction for latitude should be introduced in allowing for refraction. He showed that for the difference of latitude of Pulkowa and Washington it would make 0″·1 difference in the refraction at 45° Z.D., and might be sufficient partly to account for differences in systems of star declinations which depended upon observations at great zenith-distances. Mr. Chandler communicated a paper upon a comparative estimate of methods and results in stellar photometry. Mr. Chandler took for his text the general statement that instrumental photometry had thus far proved a failure; that is, it had not developed a more uniform scale of magnitude than Argelander's, nor had the accuracy of individual determinations been increased, but they were, on the contrary, far more uncertain than the old differential naked-eye estimates. Mr. Barnard had a paper on telescopic observations of meteor trains; whilst the closing paper was by Mr. Chandler on the use of the zenith-telescope for latitude determination.

M. THOLLON'S MAP OF THE SOLAR SPECTRUM.—About a year ago M. Thollon presented to the Paris Académie des Sciences the first portion of the great map of the solar spectrum upon which he had been engaged for more than four years. He has now given in the 'Bulletin Astronomique' for July some interesting information respecting it.

The present map is not the first M. Thollon has prepared. An earlier one, extending from A to H, was completed in 1879; but as his great spectroscope was not then finished, and was not provided with a micrometer, the positions of the lines could not be given with the accuracy he desired, so that, though this design was more perfect than Ångström's, he determined to remake it entirely, and to produce as perfect and complete a representation as possible of the solar spectrum. The present map commences with A, but does not extend beyond *b*, but M. Trépied has undertaken to carry it on to the violet. But though it thus halts at but little more than one third of the way up the spectrum, it is more than 10 metres in length, and exhibits about 3200 lines, of which 2090 are purely solar, 866 purely telluric, and 246 are considered as due to the superposition of a telluric line upon a solar one. Nor is one view only of the spectrum given. Four bands, one below the other, show the spectrum under as many different aspects. The first shows it as seen with a Sun at 80° zenith distance and the air with but little water-vapour. The second and third correspond to solar zenith distances of 60°, the former with the air near saturation, the latter with it exceedingly dry. The fourth shows only the solar lines as they would be seen when observed from outside our atmosphere. In this way a large amount of information as to the telluric spectrum and as to the hygrometric state of the air is conveyed at a glance.

The instrument employed by M. Thollon is the great spectroscope of his own design, the performance of which he finds superior to all other spectroscopes of refraction, and at least not inferior to that of gratings. Some information is likewise given as to the accuracy of the measures, which were made with a very fine glass pointer that did not hide the line it bisected. The breadth of the line was determined by noticing the part of the pointer which was equal to it in breadth, and the intensity of the lines was estimated by eye. The probable error of the position of a line is given as less than $\frac{1}{700}$ of the distance between the D lines. As to the telluric lines, M. Thollon supports the deduction of M. Egoroff that A, B, and *a* are due to oxygen. The lines of water-vapour are arranged in seven groups; and besides these, M. Thollon saw, on a single occasion, a great number of telluric lines between *a* and D, of which he could not determine the exact cause.

One of the chief purposes which M. Thollon hopes his map will serve, and which from the care and labour he has lavished upon it it can hardly fail to do, is to afford a means of ascertaining if the spectrum be invariable or not, and if changes take place, of detecting their nature and degree. In illustration of this point, M. Thollon gives a diagram of the region between B and C, as designed by Ångström and by himself, and points out some probable instances of change. Thus the line K 641, frequently seen in the prominences, is one of the feeblest in Ångström's map, but very dark in Kirchhoff's and M. Thollon's. M. Dunér has already suspected the variability of this line. The publication of this great work (it will appear in the 'Annales de l'Observatoire de Nice') will be eagerly looked for by all interested in solar physics.

Handy Map of the Moon.—Mr. T. K. Mellor, F.R.A.S., has recently prepared a diagram of the Moon for the use of amateur astronomers. The map resembles in its general character the well-known one in Webb's 'Celestial Objects,' but is much more convenient for actual use at the telescope. As it is intended merely to furnish a ready means of identifying the principal formations in the Moon and not to show details of structure, distinctness was the first object—and this has been well secured. The principal objects, to the number of 300, are given in bold outline, and their names added in clear type; the most salient features of the largest formations are also roughly indicated. The scale employed, a diameter of nearly a foot, is a very suitable one. The map cannot fail to be of great service to students of our satellite. A few notes on some of the most interesting objects in the Moon are added on the back. Messrs. Horne, Thornthwaite, and Wood are the publishers.

A generalized Theory of the Combination of Observations so as to obtain the best Result. By Simon Newcomb *.—Whatever hesitation we may feel in giving an unqualified assent to the fundamental assumptions on which the author of this paper bases his generalizations, there is no doubt that he has contributed an interesting chapter to the literature of the Theory of Errors. Indeed, in the purely analytical part of the paper Prof. Newcomb has shown himself fully competent to supply more of that beautiful analysis in which this theory is so rich. But if he has succeeded, like his predecessors, in satisfactorily developing a hypothesis, when once that hypothesis is granted, it is not to be wondered at if he should fail, where so many others have done, in presenting his hypothesis in such a form as to carry conviction to the minds of his readers.

Some new hypothesis Prof. Newcomb considers to be necessitated by the fact that with the commonly assumed law of error, large errors are more frequent in practice than theory would indicate,—that actual residuals are in fact not distributed according to the probability curve. He therefore proposes that we should modify this law so as to obtain a more flexible probability curve which may be *made* to fit a given set of residuals. The equation to the ordinary curve contains two arbitrary constants—the most probable value and the probable error. If we assume that the observations are a mixture of two groups with different probable errors, we get two more disposable constants—one new probable error, and the ratio of the numbers of observations in each group (or the probability that a given observation will fall in one group or the other). Or we may go further and assume a mixture of three groups and so on. It is obvious that by the introduction of these new arbitrary constants we can make our curve alter its shape so as to fit a given set of residuals as closely as we please, the only limiting consideration being the amount of labour involved.

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* 'American Journal of Mathematics,' Vol. viii.

But we wish that Prof. Newcomb had been able to adduce better justification for his method than an assertion of its plausibility, or even (if we do not misunderstand him) its convenience *. A considerable number of other processes might be framed on the same lines, by making slight changes in the form of the probability function; but the selection of one of these on the ground of its convenience would appear to be justified only by a demonstration that in practice they all gave much the same result. It might indeed be questioned whether much is gained by the attempt to find grounds for new hypotheses in the theory of errors. We might instance a paragraph at the top of p. 348, where the case for admission of a new hypothesis is but little strengthened by the submission, apparently as of equal value, of two considerations whose value and signification is entirely different.

Prof. Newcomb has applied his method to a discussion of the transits of Mercury. He assumes that the observations are a mixture of four groups, to which he has assigned the different probable errors $2^{s}\cdot9$, $4^{s}\cdot8$, $8^{s}\cdot6$, and $17^{s}\cdot2$ (though why this more than any other similar series is not very clear); and still having at his disposal the number of observations in each group, he chooses these so as best to fit the residuals, finding the respective proportions in the four classes to be 110, 100, 400, and 50 respectively. We can only hope that his method will be justified by a comparison of the results which he deduces by it from our present imperfect information with that completer knowledge to be attained in the distant future.

THE LICK OBSERVATORY †.—Prof. Holden hopes to make the gift of Mr. Lick one which is truly a gift to science, and not merely a gift to California and to its University. His plan for effecting this is as follows:—"We mean to put the large telescope at the disposition of the world by inviting its most distinguished astronomers to visit us one at a time, and to give to them the use of the instrument during certain specific hours of the twenty-four. Each day there will be certain hours set apart when the observatory staff will relinquish the use of the equatoreal to distinguished specialists who will come from the United States and from Europe to solve or to attack some one of the many unsolved problems of astronomy."

PROBABLE NEW VARIABLE.—Mr. Espin, in Circular No. 10 of the Liverpool Astronomical Society, calls attention to a star which was observed by Prof. Vogel and Dr. Müller on the night of 1880, Feb. 24. Their note upon it is as follows:—"Spectrum III*a*, Farbe röthlich Gelb, geschätzt $9^{m}\cdot2$, fehlt bei Argelander." Mr. Espin looked for this star with his $17\frac{1}{4}$ equatoreal on the nights of Sept.

---

* P. 352.—"The management of such an exponent might, however, prove inconvenient, and I shall adopt a law of error founded on the very probable hypothesis that, &c."

† 'Science,' Vol. viii. No. 190.

14th and Sept. 20th, but there was no star above 11·5 in that place. He thinks it will turn out to be an interesting variable. The star's place for 1885 is $\alpha=4^{h}\ 21^{m}\ 25^{s}$, $\delta=+15^{\circ}\ 50'{\cdot}7$. It lies $0^{m}\ 35^{s}\ \rho$, 0° 8′ N. of θ' Tauri.

THE LIVERPOOL ASTRONOMICAL SOCIETY.—It has been an understood thing in this Society that when a foreign country had as many as 50 members they should have the option of forming themselves into a Branch Society. Pernambuco has been the first to do this, having just sent in its fifty-first candidate, and it is believed that it will claim the privilege. Mr. G. W. Nicholls will probably be the secretary of the new branch, and we learn that he anticipates a membership of a hundred before long. We heartily congratulate the Liverpool Astronomical Society on this unmistakable evidence of prosperity and usefulness, and Pernambuco on its astronomical zeal. May the L. A. S. soon have many more such offshoots!

THE OBSERVATORY OF RIO DE JANEIRO *.—This observatory is about to be removed to a new site, which lies nearly on the same parallel of latitude as the present observatory, but two minutes further to the west. M. Cruls points out the unique advantage possessed by the Rio Observatory, in that for forty days in the year the zenith distance of the Sun in less than one degree, and the observations of it are therefore all but free from the effect of refraction. He also indicates a special use for the prime vertical instrument, which from the smallness of the laditute cannot be used with advantage for the work on which it is usually employed in high latitudes. The new edifice will permit observations of terrestrial magnetism to be carried out with success, which the old did not; it is hoped also that the photographic equatoreal to be ordered shortly will be set up on the new site, and employed in the great survey of the heavens proposed by Admiral Mouchez.

NEW MINOR PLANET.—A new minor planet, No. 260, was discovered by Herr Palisa on October 3.

Elements and Ephemeris of Comet Finlay (1886 *e*)†.

By Dr. H. OPPENHEIM.

THIS object was discovered on Sept. 26 by Mr. Finlay, First Assistant at the Cape of Good Hope Observatory. The following elements are computed from observations at the Cape on Sept. 26, at Rome Sept. 29, Vienna Oct. 1, and Albany Oct. 16. It is probably identical with Comet 1844 I.

T=1886 Nov. 21·0840 Berlin M.T.

$$\left.\begin{array}{lrrr} \omega \ldots\ldots\ldots\ldots & 304^{\circ} & 13' & 43'' \\ \Omega \ldots\ldots\ldots\ldots & 46 & 37 & 8 \\ i \ldots\ldots\ldots\ldots & 3 & 16 & 11 \end{array}\right\}\text{Mean Eq. } 1886{\cdot}0.$$

Log q .... 0·06884

---

* Comptes Rendus, Tome ciii. No. 13.

† Astron. Nachr. No. 2752.

Ephemeris for Berlin Midnight.

	R.A.			Dec.			
1886.	h	m	s	°	′	Log *r*.	Log Δ.
Oct. 31....	18	52	52	−25	57·5	0·0850	0·1056
Nov. 2....	19	0	47	25	45·2		
4....		8	50	25	31·1	0·0795	0·1012
6....		17	2	25	15·0		
8....		25	22	24	56·8	0·0751	0·0970
10....		33	49	24	36·5		
12....		42	24	24	14·1	0·0718	0·0932
14....		51	5	23	49·5		
16....	19	59	51	23	22·7	0·0697	0·0899
18....	20	8	42	22	53·7		
20....		17	38	22	22·4	0·0689	0·0874
22....		26	37	21	48·8		
24....	20	35	39	−21	13·0	0·0693	0·0856

Elements and Ephemeris of Comet Barnard (1886 *f*)*.

By Drs. J. von HEPPERGER and H. KREUTZ.

THIS comet was discovered by Mr. Barnard on Oct. 4, and independently by Dr. Hartwig on the following night.

T=1886 Dec. 24·3064, Berlin M.T.

ω	78° 56′ 20″	Mean Eq. 1886·0.
☊	140 17 55	
i	93 33 52	
Log q	9·91236	

Ephemeris for Berlin Midnight.

		R.A.			Dec.				Brightness.
1886.		h	m	s	°	′	Log *r*.	Log Δ.	
Oct.	30..	11	39	16	+5	53·2	0·1093	0·2520	2·7
Nov.	1..		45	43	6	26·6			
	3..		52	29	7	1·7	0·0916	0·2281	3·2
	5..	11	59	37	7	39·0			
	7..	12	7	8	8	18·5	0·0735	0·2031	3·9
	9..		15	5	9	0·3			
	11..		23	31	9	44·3	0·0551	0·1772	4·8
	13..		32	29	10	30·7			
	15..		42	1	11	19·2	0·0366	0·1507	5·9
	17..	12	52	11	12	9·9			
	19..	13	3	2	13	2·5	0·0180	0·1242	7·3
	21..		14	38	13	56·7			
	23..	13	27	0	+14	52·3	9·9997	0·0986	8·9

The brightness on Oct. 6 is taken as unity.

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* Astron. Nachr. No. 2752.

DECEMBER, 1886. [*Price* 1*s*.

E OBSERVATORY,

ONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Index to Vol. IX.
Royal Astronomical Society on November 12 373
Liverpool Astronomical Society 385

allacies about Observatories. By Miss MARY E. BYRD 389
des. By W. F. DENNING, F.R.A.S. 392
hing the Corona without an Eclipse. By E. L. TROUVELOT 394

dence :—

des and ε Lyræ. By Dr. F. TERBY, F.R.A.S. 396
Andromedæ. By KENNETH J. TARRANT, F.R.A.S. 397
riable. By EDWIN F. SAWYER 398

ribution of the Stars in Schönfeld's 'Durchmusterung.'—The Mass of cury.—The Leander M'Cormick Observatory.—The Natal Obserry.—The Pulkowa Observatory.—Watch and Clockmaker's Hand-—10 Sagittæ.—Gore's Nova Orionis.—The Great Nebula in Andro-a.—The Total Solar Eclipse 1886, Aug. 29.—New Minor Planets.—uld's Astronomical Journal' and 'The Astronomical Register.'—torial Note 399–403

nd Ephemeris of Comet Finlay (1886 *e*). By Dr. A. KRUEGER 404
nd Ephemeris of Comet Barnard (1886 *f*). By Drs. A. KRUEGER cc. SVEDSTRUP 404

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THE OBSERVATORY,

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and T. Lewis, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpool Astronomical Societies; Articles by various eminent Astronomers, English, American, and Continental; Correspondence on topics of interest connected with the Science; Notes on the progress of Astronomy; Reviews of astronomical publications; Ephemerides of comets, variable stars, Saturn's satellites, and for physical observations of the Sun, Jupiter, &c.; and all the usual astronomical information.

Amongst the contributors to 'The Observatory' in 1885 were Professors Asaph Hall, Holden, Hough, Pickering, Pritchard, and Young; Dr. Huggins; Revs. S. J. Perry and S. J. Johnson; Messrs. Barnard, Denning, Green, Knobel, Knott, Lynn, Tebbutt, Trouvelot, &c.

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CONTENTS OF No. 116.

PAGE
Meeting of the Liverpool Astronomical Society 345

Articles:—

Meteor Notes. By W. F. Denning, F.R.A.S. 348
A Method of Collimating Newtonian Reflectors. By Edmund J. Spitta, F.R.A.S. 349

Correspondence:—

δ Cygni. By Dr. F. Terby and the Rev. Edward Bruce Kirk 352-353
Halley and the Total Eclipse of 1715. By W. T. Lynn, B.A., F.R.A.S. 353
The Grave of Flamsteed. By W. T. Lynn, B.A., F.R.A.S. 355
On some Results of Photographing the Solar Corona by a New Method. By T. S. H. Shearmen 355
Lalande 10063. By Herbert Sadler, F.R.A.S., ... 356
Telescopic Meteors and the Height of the Atmosphere. By W. H. S. Monck, M.A., F.R.A.S. 356

Notes:—

The Binary Star OΣ 234.—The Satellites of Saturn.—The Continental Observatories.—The Pulkowa Catalogue of 3542 Stars for 1855.—A new Observatory in La Plata.—The Motion of Hyperion.—Bevis's Star Atlas.—The Second Armagh Catalogue of Stars.—Photographs of Stellar Spectra exhibiting bright Lines.—Observation des Canaux de Mars faite à l'Observatoire de Nice.—The Edinburgh Star Catalogue.—Astronomy at the American Association.—M. Thollon's Map of the Solar Spectrum.—Handy Map of the Moon.—A generalized Theory of the Combination of Observations so as to obtain the best Result: by Simon Newcomb.—The Lick Observatory.—Probable New Variable.—The Liverpool Astronomical Society.—The Observatory of Rio de Janeiro.—New Minor Planet 357-371
Elements and Ephemeris of Comet Finlay (1886 *e*). By Dr. H. Oppenheim ... 371
Elements and Ephemeris of Comet Barnard (1886 *f*). By Drs. J. von Hepperger and H. Kreutz 372

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 117. DECEMBER. 1886.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, November 12, 1886.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel, and
Lieut.-Col. G. L. Tupman.

The Minutes of the previous Meeting were read and confirmed.

Col. Tupman said that prominent amongst the 168 presents received during the recess was Vol. viii. of the Bonn Observations, containing Dr. Schönfeld's continuation of the 'Durchmusterung,' with the corresponding star charts There were also some very good photographs from M. Gothard.

Mr. Knobel. Some of these photographs received from M. Gothard are deserving of notice. In particular I would draw attention to that of the Ring Nebula in Lyra, a remarkable photograph showing the unevenness in the brightness of the ring, quite in accordance with the drawing made at Washington. These photographs have been taken with exposures of from 50 to 70 minutes, and show a large number of minute stars, some of which I have been able to identify. In the photograph of the Horseshoe Nebula all the stars are shown, but there is no trace of the nebula, whereas in the photograph of the Nebula in Andromeda, the nebula shows very strongly; the Dumb-bell Nebula is also slightly indicated. This is remarkable, because the Horseshoe Nebula is a bright object in the telescope.

Mr. Downing remarked that the Brothers Henry had photo- phed the Ring Nebula, and had obtained a small, nearly cir- ar, ring, with perfectly black centre.

A vote of thanks to the donors of the presents was then passed.

Rev. S. J. Perry read a paper by the *Rev. A. Cortie* on "Bands ved in the Spectra of Sun-spots at Stonyhurst." He said that much good work had been done, at Kensington and elsewhere, from D towards the violet, but no one appeared to be at work on the red end of the spectrum. Accordingly, Mr. Cortie and himself had set to work in this region, and had now been engaged in it three or four years. A few results were given in the present paper, and others he hoped to give in future papers. At present there were three points to which he desired to call their attention. There were two kinds of absorption, general and selective. But in the spectra of sun-spots they frequently found that, if he might use the expression, the general absorption was itself selective, that is, that it was local on certain occasions. There would be general absorption in one part of the spectrum, but it would be faint and only in a small part of the spectrum. That condition has been observed at the red end when it was not in other regions and also in special parts of the red end. With regard to selective absorption, the lines were sometimes darkened and sometimes widened. But there was another phenomenon he would call attention to, and that related to the penumbræ of these lines. Sometimes the lines were widened; at other times the dark line was not widened, but there was a shadow by the side of the line. That shadow was very frequently seen with the D lines and also with other sodium lines—two very fine sodium lines on the red side of the D lines for instance. But he wished chiefly to refer to the new bands they had observed. A good many bands had been observed in spot-spectra at Greenwich near *b*; and at Stonyhurst they had detected some similar bands in the red, two in particular—λ 6380 and λ 6383. These bands were found in the spots; but immediately one passed away from the spot the band was always lost, not only in this but in every case. This complicated spectrum of bands was obtained only in the sun-spots, as if the matter were more complicated there than in the ordinary photosphere. With regard to the lines 6380 and 6383, they had both been on one or two occasions split up into about three lines. In some cases when there were bands in the spot, in following these out into the photosphere faint lines corresponding to them were seen; but generally they were entirely lost. In regard to all these bands, there was no single one, with the exception of λ 6383, that had any lines in the ordinary solar spectrum; not one! λ 6383 was in Ångström's map, and in the two spectra published lately by Prof. Piazzi Smyth and M. Fievez. Fievez had two lines in the ordinary spectrum and Smyth had three; but, with those two exceptions, all the other bands had nothing corresponding to them in the ordinary solar spectrum. Another point was that nearly all of them corresponded with the region of the bright lines in the chromosphere observed by Prof. Young. The two points on which he would lay special emphasis were—first, that the bands observed in sun-spots had no lines corresponding to them in the ordinary photosphere, and next, that they had bright chromospheric lines corresponding to them.

Mr. Ranyard. With regard to the observations of the bands in the spectra of solar spots, one is liable to be deceived by the mere alteration of illumination of the background; and if any one will try the experiment of placing a small object some distance in front of the slit, so as to throw a shadow upon it, a shadow which would be nearly total in the centre but with a penumbra on either side, he will see apparently a considerable alteration take place in the thickness and brightness of the lines of the photosphere. This experiment raises great doubt in my mind as to the reality of the apparent broadening of the lines in spot-spectra which have been so frequently described.

Mr. Maunder. I have heard Father Perry's remarks with very great interest. Some years ago, in observing the spectra of sun-spots, I found a number of shaded bands in the region of the *b* lines on the side towards F. I was not able to find similar bands to those near *b* anywhere else, and supposed them limited to that region; but I did not examine the red end very carefully. I do not think there can be any doubt as to the real existence of those bands. They are altogether different, it seems to me, from any effect that can be produced by a mere darkening of the solar spectrum such as Mr. Ranyard has described. They were of considerable breadth and were very distinct, and in their main characteristics very closely resembled those which Father Perry has described; that is to say, for the most part we were unable to see any lines corresponding to them in the solar spectrum. Occasionally a fine line corresponding to one of the bands might be seen in the neighbourhood of the spot. I believe none of the bands were given in Angström, but one or two were represented in Fievez's Chart, and on a few occasions I was just able to break up a band into two or three fine lines, so that they presented exactly the same characteristics as those bands which Father Perry has been able to find in the red end of the spectrum [*].

Votes of thanks were passed to Mr. Cortie and to Father Perry for the paper.

Mr. Isaac Roberts read a paper on "Photographs of Stars in Cygnus." He said:—The negatives which I now exhibit were taken with my 20-inch reflector on the nights of the 17th, 23rd, 24th, and 25th August this year, and they represent parts of the constellation of Cygnus corresponding with the photographs taken by the Bros. Henry with their 13-inch refractor in June and August, 1885. The enlargements also now exhibited have been made to scale, corresponding to that adopted by the Bros. Henry,

---

[*] [I would like to add to the above remarks that the real objective character of the bands near *b* is proved by the following facts. They form a regular definite series, occupying the same positions in different spots. They are not seen in all spots, and may be invisible in the darker of two spots and visible in the fainter. They vary (so far as present observation goes) with the spot-cycle, and become less visible after the maximum is passed.

Father Perry's identification of his bands with bright chromospheric lines is very important.—E. W. Maunder.]

Mr. Ranyard congratulated Mr. Roberts on his success. His photograph of the Pleiades showed much more than was to be seen on the Henry plates. Mr. Roberts had not mentioned the beautiful way in which even the diffraction rays due to the supports of the photographic plates were shown round the images of all the larger stars down to the 3rd or 4th magnitude. The stellar point in the centre of the rays was much smaller than in the Henry photographs.

Mr. Knobel. Referring to Mr. Roberts' statement about the proportion of stars on one square inch of his own plates and on the enlargements obtained by MM. Henry, do I understand that they are on the same scale?

Mr. Roberts. Certainly.

Mr. Knobel. Then I would call attention to the fact that in the more recent photographs of MM. Henry they have succeeded in obtaining a vast number more stars than in their earlier efforts. I would instance their early and more recent photographs of the Perseus cluster. The aperture used by MM. Henry is 13 inches. I cannot say whether the time of exposure was the same in each case.

Rev. S. J. Perry. I am probably the only person in the room who has had the pleasure of visiting Mr. Roberts' observatory and examining the plates with the microscope, and comparing them with the Bros. Henry's work and the negatives with the prints. There are of course defects in the plates, and I think there is no person more willing to acknowledge this than Mr. Roberts himself. As to Mr. Common's remarks about expense, we have no difficulty here. We have unlimited generosity, and if anything can be produced for money it will be produced by Mr. Roberts. The great defect of the plate is owing to the driving-clock not being perfect; but I am happy to say that Mr. Roberts has found out the defect, and Mr. Grubb is certain that he will be able to produce a clock so accurate that no eye-watching will be necessary; that is an immense point. We talk a great deal about what Dr. Huggins has done in this matter of celestial photography, but I do not think enough is said about what Mrs. Huggins has done. It is a combination of the two. The eye of Mrs. Huggins has been fixed on the star for hours in order to keep the object in exact position. Mr. Grubb, aided by the generosity of Mr. Roberts, is pretty certain to be able to produce a mechanical Mrs. Huggins. With regard to the photographs I think them splendid, especially the No. 4, because the clock worked exceedingly well during the time that plate was exposed. As to the photograph of the nebula, every mark in the photographs of the Bros. Henry is shown in the photographs of Mr. Roberts and along with them ten times as much. I say that without any exaggeration whatever. There is no doubt Mr. Roberts has added six or seven nebulæ in that very part of the heavens which have not been suspected to exist before. He is undertaking to photograph the whole of the heavens from the North Pole down to 10 degrees below the Equator, and he hopes to be able to do that unassisted. I do not think he will be able to do that, and I think he will have to get an assistant, but so far he has done the entire work himself. I do not think we can appreciate sufficiently the magnificent work he is attempting and what he has actually done.

Mr. Common said that aperture was of the very first importance in the matter of showing faint stars. Not only was the aperture that Mr. Roberts used twice the area of that used by the Bros. Henry, but the focal length was as 100 to 132. Of course theoretically with stars that should make no difference, but in nebulous objects of a certain diameter that came into play and the advantage was very much in favour of the reflector. That the amount of nebulous matter shown was greater than that in the Bros. Henry's photographs was due entirely, he thought, to the aperture used. In the Henry photograph there was a total absence of the Merope nebula, but here there was what had never been before photographed —the Merope nebula. A picture of the Merope nebula half a degree away from the star in the direction where it had generally been shown by those observers who had seen it with the naked eye had never been seen before.

Mr. Roberts replied that the comparisons had been made between the enlarged photographs in both cases; they had been made carefully and with as little bias as possible. Mr. Common did not quite understand his point with regard to gradation. In the Henry plates the stars from the smallest to the largest, if examined with a magnifier, appeared equally bright, of course they were not the same in diameter; the same intensity of light appeared to prevail both in the 15th magnitude stars and in the brightest, which may be the 3rd or the 4th. What he meant by the gradation in the reflector photographs was that the light of the whole disk, not of a certain part of it, diminished imperceptibly from the brightest star to the faintest. The reflector, therefore, showed the stars as they were seen in looking through a telescope, and the refractor showed them without the gradation observed there.

The President then asked Mr. Maunder if he had any remarks to make on the recent eclipse.

Mr. Maunder. I did not come prepared to give any account of our doings in the West Indies. My own part in the matter was a comparatively small one. I may say that we met, both on the Island of Grenada and at Carriacou, with the greatest hospitality, and the most cordial assistance from the residents and from the officers of the two gunboats who were appointed to wait upon us and carry us to our destinations. We divided into several parties when we arrived at Grenada, in order that if the weather was impropitious in one part the entire exhibition should not be a failure; and, as it proved, the precaution was not at all unnecessary. The South of Grenada was occupied by Capt. Darwin, Dr. Schuster, and

Professor Thorpe; Mr. Turner and Prof. Tacchini went to the east coast of Grenada; Mr. Lockyer to Green Island, off the north-east point; and Father Perry and I went 20 miles further north to the Island of Carriacou. On the morning of the eclipse the Sun rose in a fine sky, but almost immediately afterwards heavy banks of clouds came up, and before the first contact the Sun was hidden and we had a smart shower a little before totality which obliged us to cover up our instruments; but fortunately before the Sun was entirely eclipsed the clouds cleared away and we had a very good view of the eclipse in a clear portion of the heavens. About two minutes after totality was over the clouds began to gather again and a second shower came on very shortly after. At Green Island Mr. Lockyer was unfortunately able to see nothing. The clouds which had so nearly spoiled our view entirely concealed the Sun from him. The observers on the east coast of Grenada and on the south had a clear sky during part of totality; they each, however, lost a certain number of seconds. Prof. Thorpe made a very successful series of observations of the intensity of the coronal light. Capt. Darwin obtained a number of photographs of the corona. He photographed the Sun both before totality and during totality, his purpose being to test Dr. Huggins' method of photographing the corona in full sunshine, and, so far as it appears, the result of his photographs is to negative the idea that Dr. Huggins has been successful.

Lt.-Col. Herschel. Not to support him?

Mr. Maunder. Yes, not to support him, that is more correct. Dr. Schuster secured two photographs of the spectrum, one with the slit radial and one with the slit tangential. I think both will be very useful—one certainly will; and he also obtained five photographs of the corona, of which three are very fine. I got seven photographs of the corona, of which five are good. I was not successful with the photographs of the spectrum. Father Perry and Mr. Turner observed with the spectroscope. Mr. Turner was able in some degree to confirm the observations which Mr. Lockyer made in Egypt in 1882. Prof. Tacchini made some very interesting direct spectroscopic observations. Perhaps the one of the greatest interest was that he showed that the prominences we see with the eye during a total eclipse are not precisely the prominences which we see by the spectroscopic method in full sunshine; the prominences seen in the eclipse are larger than those seen by the spectroscope, and in their upper portions they give a continuous spectrum. I think those are the principal points we have as yet gathered. There was one little point of which Mr. Knobel has reminded me. Although I was looking at the corona with the eye all the time I was taking photographs, and I had a good view of the eclipse, yet I never saw any red flames. I saw one or tw prominences, and they appeared as a bright silver-white, and I hav identified them on the photographs since. There is no doubt I sa real prominences, but they did not produce the slightest effect red or rosy colour on my eyes. I should have said the prominences were of a pure white; I saw no trace of colour in the chromosphere or prominences. I suppose that was some physiological defect in my eye at the time, but I think it worth while to mention it.

Mr. Brett. It is no physiological defect at all. The prominences are mostly white; they are only occasionally red.

Mr. Knott. Were there not some observations of Prof. Tacchini on the flash?

Mr. Maunder. Yes, there were, but I cannot quite help Mr. Knott in that respect, as I was not able to ascertain precisely what Prof. Tacchini had actually seen. I notice that he has published a report in the 'Atti della Accademia dei Lincei,' but I have not read it yet, so I cannot speak precisely on the subject; but I judge that he proved that what has been called Young's reversing layer lies at a much greater height than had been before imagined. The spectrum of bright lines seen at the moment of totality was at one time generally believed to be due to the very lowest layer in the Sun's atmosphere, and to be a simple reversal of the Fraunhofer lines, but Prof. Tacchini seems to have traced it to a much greater height from the Sun.

Rev. S. J. Perry said that the members of the Expedition had to experience some inconveniences—it had not been wholly a pleasure trip. Thus Mr. Maunder had suffered somewhat severely from the attacks of mosquitoes; but such drawbacks were more than counterbalanced by the unlimited kindness and help they received on all sides. Mr. Drummond, at whose house they stayed whilst in Carriacou, abandoned both his bedrooms to the members of the Expedition, and slept on a couch in a sitting-room. Captain Masterman, from whom they received the most valuable assistance (as indeed he, Father Perry, had always received from all naval officers with whom he had come in contact on other astronomical expeditions, and he trusted he should never go on an expedition in which he had not a captain of H.M. Navy near to help him), gave up his own bed in his cabin and his own mosquito-net. With regard to the red prominences, he thought he had never seen a more beautiful sight in his life than the projected image of the prominences and corona on the slit of his spectroscope. He employed an Alvan-Clark refractor that had been grandfathered by Dawes, and the Rev. T. W. Webb had used it in all his work. But the prominences were small and might be missed by the naked eye. He only wished he could have spent his time in making drawings of the beautiful picture he saw on his slit; but his work was to find carbon, if he could, so as to confirm or overthrow the observations made by Prof. Tacchini in 1883, who was supposed to have seen the spectrum of carbon in the corona during the observation of the total eclipse at Caroline Island. It was very important to test that observation; and Prof. Tacchini had himself gone out for that purpose. He (Father

Perry) had instructed his assistant to place the slit at different distances from the Sun's limb, but he looked in vain for carbon wherever it was placed; Prof. Tacchini, too, wholly failed to see it at his station. The search for carbon occupied the time of totality; but before and after totality, Mr. Lockyer's theory respecting the successive layers of the Sun's atmosphere was to be tested. Mr. Lockyer supposed that, proceeding from the photosphere outwards, the absorption causing the dark lines of the spectrum took place in different portions of the solar surroundings—not all in one layer, Young's layer or Secchi's layer, but in successive layers. The portions near the Sun would be more strongly illuminated than the portions further off. Therefore it was expected that in the small portion of the spectrum under examination some very short lines would be seen, due to the part of the solar atmosphere immediately touching the photosphere, because they were brightest and would come out first. A second or so later the Moon would have covered more of the solar surface, and there would be a greater extension of those lines, and some longer lines would appear in the field of view, but those short bright lines would still remain there. Just before totality the fainter lines would come out, and the lines previously seen would become more bright, but would retain the same length as before. Mr. Turner, he believed, saw two short lines which appeared before the longer lines, and that observation might be considered as a probable confirmation of Mr. Lockyer's view. He (Father Perry) saw line 1474 K very distinctly, the very first line he saw, and after that he saw about 15 lines near little *b*, and those of different lengths; so that he thought the observations they had made were in favour of the theory that the solar atmosphere consisted of successive layers. He did not think it necessary to add anything more to what Mr. Maunder had put before them, but he could fully confirm everything he had said.

Mr. Stone. May I ask if there was a great extension of the outer corona in the last eclipse?—whether there was any relationship between the plane of the ecliptic and the Sun's equator and the extension of the outer corona?

Rev. S. J. Perry. Some astronomers had rather expected that we should have something like the corona seen in 1878, when we had rays coming out from the poles and a great extension in the direction of the equator. Disks had been made in order to hide the brightest part of the corona, so that its extensions might be seen as far as possible; but we did not get a corona of that shape at all.

Mr. Stone. No one saw it?

Rev. S. J. Perry. No one saw a corona of that shape. Captain Masterman, captain of the 'Bullfrog,'—who is an exceedingly good artist and generally spends his spare time on shore in making sketches, so that he was a good person for this work,—saw more or less the same picture that is represented in the drawing taken near Manilla in 1868. The eclipse of this year is a repetition of that eclipse. They saw rays extending a very considerable distance from the Sun, perhaps two or three diameters, but nothing like what Prof. Langley saw in 1878. There were two rays nearly 90° from each other, and the one on the apparent left did not extend so far as the other. I saw another ray between the two, and other rays were seen below the Sun which did not extend so far as the first; but there was not that great extension in the direction of the equator that some expected.

Mr. Stone. Why I asked the question was because I know that in the only eclipse I ever saw those extensions were very prominent when once caught sight of, but might be readily overlooked. There was a curious illustration afforded of the faintness of the light of the extensions as compared with the light of the prominences and inner corona, which I think I have mentioned before. There were two people, sitting together, making drawings of this outer corona, and they had disks prepared and vertical lines drawn, and just before the end of totality one of them (who was an engineer and had made some very careful drawings of the inner corona) drew it without that large extension that Father Perry says one of the observers saw, and looking suddenly at the other's drawing, he wanted to know what was the meaning of this extraordinary extension of the second drawing. Fortunately the eclipse was not over, and the one who had drawn the large extension called the attention of the other person to it, and he saw it also when his attention was directed to it. In the original drawing among the MSS. of the Society, you will see he began to fill in rapidly this outer corona, but the eclipse was over before he had time to finish it. I asked the question, because it is one of those points which can be easily overlooked unless it fairly attracts attention. If there is any positive evidence that one person whom we can trust saw it, I should rather say it was there still, though some may have overlooked it.

Mr. Maunder. I think that the observers with the disks would all have seen the extension if it was possible to be seen, because they were all instructed to look for faint extensions. With regard to the extensions that Captain Masterman saw, Father Perry has said, although he traced them to a considerable distance from the Sun, that they were nothing like the distance of the streamers seen in 1878. I think in 1878 they were traced as far as six degrees from the Sun, or 12 diameters.

Mr. Roberts. 10,000,000 miles.

Mr. Maunder. That would be 12 diameters. Captain Masterman traced this longest ray between 5 and 6 diameters; but it was not an equatoreal ray and not in the same direction as the rays seen in 1878.

Mr. Brett called attention of spectroscopic observers to the fact that when they were looking along the limb of the Sun they were looking through many layers of the Sun's atmosphere, and at very varied distances from the Sun's surface.

Ten Members were elected and 33 Candidates were proposed. Messrs. T. G. Elger, F.R.A.S., George Knott, LL.B., F.R.A.S., and A. Cowper Ranyard, M.A., F.R.A.S., were elected Associates. A paper by Mr. K. J. Tarrant was read on the micrometrical measures of twenty-five double stars. The study of double stars was perhaps less interesting than lunar or planetary work; but the more the subject was investigated, the more absorbing it became. By this he did not mean the mere attempt to split double stars, but rather a systematic study of those pairs where a motion was suspected or had already been discovered. He knew of no more wonderful result than to discern for themselves that the great law of gravitation extended to the far-off depths of space. The micrometrical measurement of double stars required three things—a good telescope, a reliable micrometer, and an inexhaustible stock of patience, as, in the cases of close stars, the observation would have to be repeated many times before results of any value could be attained. It was, however, a most important undertaking, and ought to be of the greatest assistance to the computers of a future generation. An accurate knowledge of their previous positions would enable them to calculate with certainty the amount of the proper motion, and might possibly disclose other interesting facts. This knowledge they did not themselves possess; but it was their duty to provide it for others who followed in their footsteps.

In a paper on the Masses and Distances of Binary Stars, Mr. J. E. Gore, F.R.A.S., said:—"When the parallax of a binary was known and the elements of its orbit satisfactorily computed, it was easy to find some of the masses of the component stars, in terms of the Sun's mass, and the real dimensions of the orbit. The parallax of a few of them had been ascertained. First, there was the famous binary star α Centauri, which, as far as was known, was also the nearest star to the Earth. From its orbit, computed by Dr. Hind in 1877, combined with a parallax 0″·928, he found the mass of the system = 1·79 times the Sun's mass, and the semi-axis major 23·49 times the Earth's mean distance from the Sun. Assuming the latest elements found by Dr. Elkin (semi-axis major = 17″·50, and period = 77·42 years) and his parallax of 0″·798, he found the sum of their masses = 1·759 and the semi-axis major = 21·13 times the Sun's mean distance. Second, η Cassiopeiæ. Dr. Dunér found for this binary a period of 176·37 years with semi-axis major = 10″·68. Combining these elements with OΣ parallax of 0″·154, Mr. Gore found the mass of the system = 10·722 times the Sun's mass, and the mean distance = 69·35. The magnitudes of the components were about 4 and 7·6. So they had a star of the 4th magnitude with a mass about 6 times as great as that of α Centauri. The calculations of the elements of the well-known companion to Sirius were still more interesting; and there was no doubt that it was in rapid orbital motion round its primary, probably with a period of about 49 years.

He had found the mass of this system = 71·63 times the Sun's mass. Assuming the attraction of the companion to be the cause of the observed irregularity in the proper motion of Sirius, Auwers found that its mass must be about one half that of Sirius. Thus we had the mass of a 10th magnitude star absolutely greater than that of the Sun!"

Mr. W. S. Franks, F.R.A.S., followed with a paper on the Magnitudes of Double Stars, the determination of which he considered of great importance to astronomers. The old and well-known division into magnitudes was both vague and arbitrary; and, though it might never be entirely superseded, was certainly capable of much improvement. Sir John Herschel was one of the first to recognize the shortcomings of the prevailing system, and to suggest the better plan of indicating the exact brightness of the stars on a photometric scale. The reform thus inaugurated had been developed by Seidal, Wolf, and Zöllner on the Continent, Pritchard in England, and Pickering in America, each of whom used some special form of photometer. Undoubtedly the most valuable work of the kind was that by Prof. Pickering, published in vol. xiv. part 1, of the 'Annals of Harvard College Observatory,' both for the elegance of its methods and the completeness of the results. It contained the photometric magnitudes, expressed to the nearest tenth part, of 4260 stars, being the mean results of some 100,000 separate measures. They might consider, then, that the true equivalent magnitudes of the naked-eye stars for a certain epoch had been satisfactorily ascertained and defined, though much still remained to be done before our knowledge of stellar magnitudes could be considered in any sense complete.

Mr. W. H. S. Monck, M.A., F.R.A.S., had framed some theories which he thought explained many of the singular appearances presented by the Moon. The most noteworthy of these features were the absence of water and the great number of extinct volcanoes. Taken together, this was rather startling, and quite unaccountable by terrestrial analogy, inasmuch as volcanic action on the Earth appeared to be intimately connected with water. There was abundant indication of the former existence of water on the Moon; and, he argued, this could not have been withdrawn into the interior, as had often been suggested, without provoking fresh volcanic outbursts. He rather attributed its disappearance to continual exposure of one side of our satellite to the heat which was radiated from the Earth. It was more than probable that this heat, combined with an exceedingly low atmospheric pressure, had vaporized the water, which would thus be carried to the opposite and colder side, and there condensed, if not frozen. Mr. A. Newton Harris considered it unsafe to expect terrestrial occurrences to explain lunar appearances, which were in themselves quite beyond the range of our experience, at least as regarded volcanic origin. At the same time they naturally sought an explanation from analogy, and he had found what *he thought to be* the key in the "Atolls" and coral formations of the South Pacific and Indian Oceans. In the clear water of those regions the sea-bottom represented ring-mountains to perfection, and, granting a subsidence of the land and a disappearance of the water, they would have a pretty near approach to lunar scenery.

In a description of some remarkable sun-spots that were visible during the first fortnight in May 1886, Miss E. Brown said that in many instances they were both unusual and striking. How immense this group of spots really was could only be realized by calculating its relation to the whole area of the Sun's visible surface. According to Mr. Maunder, of the Royal Observatory, twenty-five of our earths might have lain side by side in this remarkable group. The group remained, almost without alteration, from the 2nd to the 11th of May, though towards the end of that period an alteration in its outlines gave warning that its dissolution was not far off. This, indeed, proved to be the case; for though some fragments reappeared during its succeeding revolution, their aspect was so different that it was doubtful if even it was the same group.

M. B. Lihou contributed an account of some observations which had led him to suspect a variation of light in the companion to Polaris. The idea was, he said, first suggested by the remarks of Mr. Isaac Roberts ('Bulletin Astronomique' for March, 1886) with regard to the different times of exposure which he had found necessary to photograph this star. The duration of this exposure had varied from 4 secs. to 60 secs., and even in one instance to 15 minutes. This discrepancy seemed unaccountable, except by an actual variation in its light, and M. Lihou had commenced a careful series of observations in order to test whether this was the case. The observations were made with a 4-in. refractor; and the variations were estimated from 9·5 to 10·5 magnitudes, the period being about 21 days.

In the second paper, on "The Moon surveyed in Common Telescopes," Mr. T. G. Elger, F.R.A.S., included the Mare Humorum and its surroundings. The 6th of next month (December) would be favourable for reviewing that district; especially for studying the remarkable contour of the western border and the curious ridges which traverse it. These latter deserve more than a passing notice, not only on account of the beauty of their form, but as exhibiting peculiarities of arrangement which tend to throw a ray of light on their origin. Their tendency to follow the curvature of the western border, like ripple-marks imprinted by the tide, was very noteworthy. This tendency was not confined to those on the surface of the Mare Humorum, but might be traced in numerous other regions. The western border of the Mare, with its superabundance of complicated detail, included many remarkable objects, among them the incomplete ring Hippalus and other smaller formations. The former looked as if it might have been breached by the pressure of an accumulation of the material within its borders, and which overspreads the Mare. The eastern side afforded still more interesting examples of these now incomplete rings than Hippalus. Lee and Dopplemeyer had clearly been destroyed on the side facing the Mare. In the case of the latter, when it was close to the terminator, distinct traces could be seen, even with small apertures, of a former border in the shape of a low mound which extended across the opening.

Mr. W. F. Denning, F.R.A.S., also contributed a second paper of his valuable series on "Telescopes and Telescopic Work."

Popular Fallacies about Observatories *.

During the years that my life has been well nigh lived in an observatory, I have felt that some things are viewed differently by those without and those within the walls. One does not willingly try to dispel pleasant illusions, and yet, since an observatory with all its domes and piers, appliances and instruments, is designed for the search of truth, standing so near its corner-stone, I ask your leave to speak the truth frankly for a few minutes.

It has seemed to me that, in the popular imagination, an observatory exists for the purpose of being visited—like a parsonage; or that it is held to be some grand celestial amphitheatre where there are nightly shows of moon and stars and planets, with the astronomer for chief showman; that he delights to exhibit in the fields of his telescope comets' tails, Jupiter's satellites, Saturn's rings and pretty things, much as Barnum likes to show trained elephants and dancing ponies. Now, as a matter of fact, astronomical benevolence does not usually lie along these lines. The observer places a high value on his time, especially the time of clear evenings. Indeed, I fear he is sometimes tempted to say with the poet:—"Who steals my purse, steals trash; but he that filches from me my clear nights, robs me of that which not enriches him and makes me poor indeed." He feels as the Englishman does about his home; his observatory is his castle, and when some clear night he is fairly at work with transit instrument, meridian circle, equatorial or photometer, the casual, unannounced visitor is just about as welcome to him as brigands to the traveller in Spain, or Irish Moonlighters to the English landlord, just about as welcome; and if the plain truth were known, not much more so. Now when I build my observatory—it is to be in California—I invite you all to the laying of the corner-stone in 19—, I have fully decided that I shall have a moat and a drawbridge; about armed sentinels I have not quite made up my mind. On that point I am still willing to be laboured with by my more generous-hearted friends. But then if any of you should come (a friend from Northfield would be so welcome) I don't doubt you could look through my telescope all night in spite of moat, drawbridge, and sentinels.

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* Delivered at the laying of the corner-stone of the new Astronomical Observatory of Carleton College, Northfield, Minn. Reprinted from the 'Sidereal Messenger.'

Almost everyone else has some power in arranging and controlling the time for his work, but the astronomical observer has absolutely no control over the conditions that make his work possible. He cannot make the sky clear, the air steady, or star-disks sharp cut. As a noted astronomer has said:—"The work he fails to do to-night, he may wait weeks, months, possibly years, for another opportunity to do": so perhaps he is not very unreasonable when he asks only for a chance to do his work.

That word, work, hardly corresponds with popular ideas. It is commonly fancied that there is a great deal of poetry and romance within the walls of an observatory. All have read the ancient legend of Tycho Brahe, how he went to the observatory in velvet robes of state as if the presence of the stars was the presence of princes. And people fancy that here at midnight, in star-lit domes, you almost hear the music of the spheres. They picture to themselves the observer seated at his telescope, hour after hour, looking down, down into deep lunar craters, feasting on delicate nebulæ and swift-flying comets, or revelling in gorgeous star-clusters. Here, they think, night after night before his rapt vision, there passes all the panorama of the heavens, multiplied and glorified a thousand fold by his powerful lenses. I have sometimes wished that it were so; but it is work that goes on in an observatory, work as stern and exciting as that of the factory.

I raise no objection to poetry or velvet gowns, but until some one invents a way of lighting telescopic fields so that the observer is not obliged constantly to handle greasy lamps, the question is not open for discussion; the banns between poetry and practical astronomy are positively forbidden. Why, I do not believe even Tycho Brahe himself could have kept grand and stately with grease trickling down his hand! No, the modern observer is mindful of sulphuric acid and sperm oil, and dons an old coat or a shabby dress, as the case may be, and could you look within the walls of the observatory you would not find him idling or dreaming. He moves with a quick brisk step, casts a hasty glance at the sidereal clock, notes that the batteries are in working order, the electric circuits without breaks, proper connections made, winds the chronograph, puts on the sheet, sets it in motion, and a little later perhaps you see him ready for work with the meridian circle; but it is hardly likely that he is seated in one of those easy observing carriages that you have seen pictured in some advertising page, and set down in your mind as one of the manifold luxuries of an observatory; it is more probable that some home-made contrivance or a mere dry-goods box answers his purpose. His hand is on the key, his eye is at the tube, he turns and looks up, but it is with no ecstatic gaze, he is noting the clearness of the sky and the danger from some fleecy clouds near the zenith; again he looks through the glass; there is a succession of short sharp taps, that means the star is in the field of view; another tap, the star has crossed the first wire of the meridian-circle. Then there is a series of taps, microscopes are read and recorded; another setting is made, and then operations may go on for several hours varied by tying a knot in the chronograph cord, shaking up the stylographic pen, and doctoring the greasy lamp. "And is this all?" you say. "He just puts his finger down there when a star crosses a wire, why a child could do that!" Yes, a child might do it after a fashion, and yet one of our excellent American astronomers, especially skilled in work with the meridian-circle, has said it takes years to become proficient in that simple thing. He was too modest to add how much skill and talent were required, and it were better that I left to some one far wiser than I to tell how much of the eternal truth of the stars has been deciphered and brought within the grasp of the human mind mainly by the exact bisection of a star as it crosses the wires of the meridian-circle. And so you might follow the observer from room to room in his work with different instruments and you would find his duties made up of a large number of petty details, no one of which shows the skill required or the results involved.

Indeed, I think the observer himself is a different sort of personage from that he is commonly imagined to be. He does not dwell constantly in a state of ecstacy or enthusiasm; he does not require a dictionary of superlatives to express his feelings about the stars; he does not stay up late nights to look at pretty things through his telescopes. He is, perhaps, rather indifferent to merely pretty things, and may shock some entranced visitor by his utter lack of proper emotion over some telescopic spectacle; but he will spend his nights for weeks and months in painstaking observations, making hundreds of measures of angle and position; he will give up his days to laborious computation, and all for what? Why just to find out that two insignificant stars in the heavens (one of which the unaided human eye will never see), to find out that they form a system, are bound together by the force of gravitation, the one moving in a path about the other in an orbit that he can map. It seems a prosaic result, and yet such truths as that are worth a world more to the earnest observer than years of pleasure hunting in fields sown thick with glittering stars. He is not looking for amusement or beauty, he is seeking the truth, if happily he may find it. He longs to find out, to understand, to know; behind form and motion and colour, he seeks the unchanging verities.

No, it is not to found a palace for dreams, a place where the fancy may feast on swift-changing star pictures, that the walls of an observatory go up. It is to establish a place where truth is sought. I know that there are those who think that an observatory is a monument to human pride and human intellect, and the truth found here appears cold and visionary, without power to warm the human heart or make the world better. To me it seems that God made human minds hungry for all truth and that he says to the observer here, as well as to the disciple of old—"Seek, and ye shall find."

MARY E. BYRD *.

Meteor Notes.

ON Oct. 22 I observed 26 meteors during a watch of $3\frac{1}{2}$ hours before midnight. The stars were somewhat dim in haze and fog, and now and then a few clouds passed over. The only definite shower was from near α Ceti at 43° +5°, which yielded slow, small meteors. This system has been previously noticed as follows:—

1869, October 14 . . .	44° +4°	Tupman.	6 meteors.
1879, October 20	45 +6	Denning.	8 meteors.
1872, October 30	40 +6	Backhouse.	9 meteors.

On Nov. 2, in $2\frac{1}{2}$ hours, between $10\frac{1}{2}^{h}$ and 13^{h}, I counted 24 meteors in a sky so much suffused with fog that at low altitudes bright stars were hardly perceptible. Large meteors from Taurus were very frequent; they numbered about half the total seen during the night. The centre was at about 55° +9°, but the radiant seemed diffused over some 5°. It is certain that the Taurids observed early in November differ greatly as regards their place of emanation to those seen later in the month. On Nov. 20, 1876, they were shooting from 62° +$22\frac{1}{2}$°, and on Nov. 27, 1880, from 63° +21°.

On Nov. 3, in $3\frac{3}{4}$ hours, between 11^{h} and 15^{h}, 38 meteors were enumerated, including some additional Taurids; but the shower quite failed to maintain its very pronounced character of the preceding night.

Of the minor streams in play on Nov. 2 and 3 the following appeared the best:—

1.	32° + 8°	4.	60° +27°
2.	38 +20	5.	70 +61
3.	48 +21	6.	97 +42

Nos. 2 and 3 represent a pair of showers in the E. region of Aries. From a comparison of various observations ('Astronomical Register,' May 1884) of the radiants S. of Musca, I found three main centres, namely:—

1.	41°·0 +21°·2	Average of 6 radiants.
2.	46 ·2 +26 ·8	" 5 "
3.	47 ·3 +21 ·5	" 4 "

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My results obtained this year confirm the first and third of these. The latter seems especially well defined. In 1883, Nov. 4–10, Mr. Backhouse saw 18 meteors from 48° +21°, which is precisely the same point as that I derived this year; and I found the radiant of 17 variously observed fireballs at 48° +22°, Oct. 25–Nov. 6 ('Monthly Notices,' Vol. xl. pp. 35–37).

Three brilliant meteors have been lately recorded here:—

1886.	h m	Mag.	From	To	
Oct. 23 ...	9 40	♃	116° +59°	155° +49°	Very slow.
Nov. 2 ...	11 48	♃	21 +52	2½ +45	Very, v. swift; streak.
3 ...	11 49	♃	20 +23½	10 +19	Not swift; train.

The first of these had its probable origin in Aries. The one seen on Nov. 2 was a brilliant, flashing meteor from east of β Aurigæ, 97° +42°; and that of Nov. 3 was from a radiant I suspected S. of ε Persei, at 62° +33°, and which I had seen in prominent activity on Nov. 3, 1877.

A magnificent meteor was seen by many people at Bristol, Swansea, Tenby, and at other places in the west of England on Nov. 2 at 8^h 5^m. It is evident from the descriptions that it was a fireball of the largest type; and its path as observed here by my brother, Mr. C. P. Denning, was from 296° +40° to 272° +25° =25°. This is confirmed by an acconnt from Mr. G. Langford, of Pensford, who states the meteor started from the vicinity of α Cygni and took a vertical course to the horizon. The path was, however, not quite vertical, for, according to the best accounts, the fireball descended between the stars of Cygnus and Lyra with a slight inclination towards α Lyra or to the west. There can be little doubt it was a fine Taurid, for its path conforms with the radiant at 55° +9°, from which I recorded 11 bright meteors later on the same night. At some places in South Wales the fireball was astonishingly brilliant. At Maesteg it is described as leaving a streak or trail of vapour for two or three minutes, and it was believed that "fragments of the body may have fallen in the neighbourhood of Bryn or Pontrhydyfen. All who witnessed it said it was the most wonderful meteoric phenomenon they had ever seen."

Large fireballs from Taurus and the region east of Aries (S. of Musca) are very frequent during the first week in November, as I have several times pointed out ('Observatory,' Vol. iii. p. 131, and Vol. viii. pp. 24, 25). But the Taurid fireballs of Nov. 1–8 are probably quite distinct from those of Nov. 19–23 and 27, as there is a difference of 15° in their radiant-points.

On Nov. 17, at 7^h 18^m, another fireball was observed here. I saw it first as a small yellowish-white star in Perseus; but it rapidly increased in brightness until, after several marked fluctuations, it must have exceeded by many times the lustre of Venus. The whole sky was lit up. As the fireball slowly fell to the N. horizon, it cast off a string of sparks, but there was no enduring train or light-streak. The apparent path was from $32\frac{1}{2}° + 45°$ to $158° + 55° = 63°$. Duration of flight, 7 seconds; the motion was therefore very slow. Radiant-point probably a few degrees S.E. of α Arietis. The great variations in brilliancy formed its most striking feature. W. F. Denning.

Bristol, 1886, Nov. 18.

Photographing the Corona without an Eclipse.

The failure of Dr. Gill and of Capt. Darwin to obtain a picture of the Moon projected on the corona during the last total eclipse of the Sun cannot decide the question one way or the other as regards the true character of the photographs taken in 1883 by Dr. Huggins' method, because it cannot be attributed exclusively to the faintness of the corona in ordinary circumstances, but rather to other causes having no direct relation with the subject. We know that at Prickly Point at least the state of the sky was not very favourable for such a delicate operation, and, furthermore, that the corona was particularly faint as compared with what it has appeared in former eclipses.

The corona in full sunshine is undoubtedly a very faint object and the least traces of vapours in the sky must reduce it considerably and, when more abundant, overpower its light completely. In order to succeed in photographing this delicate object, even during an eclipse, the sky around the Sun must be blue and perfectly pure. But since the fall of 1883, the Sun has been constantly surrounded by a vapory, luminous halo, which, although it has of late considerably subsided, may yet have been sufficient, with the causes above enumerated, to have overpowered the light of the corona during the last eclipse, and prevented its action on the sensitive plate.

I have never seen the photographs taken by Dr. Huggins in 1883, and I am therefore unable to form an opinion as to their coronal nature. At the Blois Congress, however, I have been shown by Mr. Tiesserenc de Bort, a negative of the Sun obtained in Switzerland in 1884 by Mr. Ray Woods, but I was unable to make out any thing giving the evidence of the corona upon the extended halo of light surrounding the Sun's image. Although I was unable to recognize traces of the corona upon this particular plate, yet the various phenomena I have observed at different times somewhat induce me to believe in the possibility of photographing the corona in the absence of an eclipse, and I am therefore inclined to believe Dr. Huggins did succeed in 1883 in obtaining traces of it. The want of success of Mr. Ray Woods in Switzerland and at the Cape can be sufficiently explained by the very strong halo of light then surrounding the Sun. Until, then, the Sun is entirely free again from this vaporous envelope, the chances for photographing the corona will be poor.

It is well known that, during various eclipses, many observers have seen the Moon projected on the corona several minutes before and after the beginning or end of totality. During the eclipse of July 29th, 1878, and while I was earnestly observing the decrease of the thin solar crescent, my attention was called on the opposite side, $2^m\ 15^s$ before totality had begun, by the brilliant coronal light issuing from behind that part of the Moon's western limb not yet entered on the Sun. During the same eclipse the Moon was again seen projected on the silvery light of the corona, and was only lost sight of $3^m\ 22^s$ after the end of totality. (See U.S. Naval Observatory Report on the total solar eclipse of July 29, 1878; appendix iii. p. 85).

During most part of the partial phases of the eclipse of May 6, 1883, the Moon's limb could be traced without much difficulty on the corona 3′ or 4′ beyond either of the solar cusps; and 3^m before the beginning of totality the light of the corona was seen behind that portion of the Moon's limb not yet projected on the Sun. (See Comptes Rendus de l'Acad. des Sciences, vol. xcvii. p. 596.)

During the partial eclipse of the Sun, Dec. 31st, 1880, the presence of the Moon and of the coronal light were perfectly recognizable with the spectroscope to a distance of 3′ or 4′ from the Sun's limb. The slit having been placed perpendicular to the Moon's limb and close to the Sun, the border of our satellite could be recognized, the Moon giving a darkish continuous spectrum, while the corona gave a brighter continuous spectrum. It was even ascertained in the same way that the corona was brighter on the western than it was on the eastern side of the Sun. (See 'Science Observer,' vol. ii. p. 9.)

Some time after my return from the eclipse expedition of 1878, I had an opportunity of observing an impressive phenomenon which is yet fresh in my mind. It was about two o'clock when, going to my observatory, the brilliant light of the shining Sun rapidly faded away. Looking up to see the cause of this sudden diminution of light, I saw half a dozen small, roundish, and intensely black clouds in the vicinity of the Sun, and one of them in passing centrally over our luminary had completely eclipsed it.

With the exception of these few inky black cloudlets, the sky was perfectly blue and clear. Around the cloud intercepting direct sunlight a soft silvery light, recalling vividly in my mind the corona seen around the Moon at Creston a few months before, was to be seen. It was not an extended and uniformly illuminated aureole, such as is now and then to be seen, but it was composed of appendages of various forms, and extended farther on the east than on the opposite side. The phenomenon lasted a few minutes, and vanished with the reappearance of the Sun.

As the Sun was high, the sky blue and absolutely free from clouds or vapours, and the appendages not radial or in straight lines, they could not be of the same nature as the rays sometimes formed by the illumination of vapours by the Sun's light passing through small openings in the clouds. What I saw so strikingly resembled the corona, that I did not doubt an instant but that I was witnessing that phenomenon. Now that I have acquired a slight knowledge of photography, I have not the least doubt that, had a plate been exposed at that time, the corona would have left its mark on its sensitive film, almost as well as during a total eclipse.

This last observation is suggestive, and perhaps it would be worth while trying whether, by placing a disk of proper dimensions at the top of a high mountain situated at a distance, the corona (photographed according to Dr. Huggins' method) would leave its impression upon a sensitive plate exposed at the moment that the Sun was artificially eclipsed by the disk.

The preceding observations show abundantly that, in former eclipses the light of the corona was bright enough to show the Moon projected upon it as a conspicuous object to the eye; and there seems to be no question whatever that it could have been photographed, even at a distance of 3′ or 4′ from the Sun's limb. The failure of Dr. Gill and Capt. Darwin to get a picture therefore cannot be attributed to the impossibility of photographing the Moon upon the corona in ordinary circumstances, but to other causes; and those referred to above—viz. the faintness of the corona, the unfavourable state of the sky, and the luminous halo surrounding the Sun—are sufficient to explain it.

Observatoire de Meudon,
Nov. 10th, 1886.

E. L. Trouvelot.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Pleiades and ε Lyræ.

Messieurs,—

Je crois qu'il sera agréable à plusieurs de vos lecteurs de l'*Observatory* d'apprendre les résultats de quelques observations que j'ai faites des *Pléiades* avec mon équatorial de 8 pouces de Grubb. Je dirai d'abord qu'avec un oculaire de Ramsden, à grande lumière, dont le champ est de 45′, je vois parfaitement la faible nébuleuse de Mérope; cette nébulosité se présente dans mon instrument avec la forme que lui attribue Tempel, c'est à dire en forme d'angle

dans le sommet du quel est plongée Mérope. Je me suis servi, comme repère, de la carte représentant la photographie de MM. Henry, publiée dans le rapport de l'Observatoire de Paris et j'ai constaté, par une observation soignée des environs d'Alcyone, que cet oculaire de Ramsden me montre les étoiles de 11^e et 12^e grandeur de la carte. L'oculaire grossissant 150 fois *environ* montre ces étoiles d'une façon saillante et il découvre aussi celles de 13^e grandeur. Cette dernière grandeur m'a semblé être la limite, ou à très peu près, de la puissance de pénétration de mon objectif, pendant la soirée principale de ces observations, qui, il faut le dire, était légèrement *brumeuse.* Je voyais aussi, incontestablement, d'autres points plus faibles qui apparaissaient et disparaissaient fugitivement, et dont plusieurs même ne m'ont point paru figurer sur la carte. La 13^e grandeur de l'échelle de Struve nous mène à la 20^e d'Herschel et au delà et c'est ainsi que le compagnon de μ Andromedæ lui-même n'échappe pas à la pénétration de mon instrument, comme j'ai déjà eu le plaisir de vous le dire.

Je ne puis encore rien dire de Saturne si non que, dans les conditions défavorables où je l'ai observé, j'ai constamment reconnu les satellites Titan, Rhéa, Téthys et Dioné.

Je n'ai pu juger encore de la photographie d'ϵ Lyræ obtenue par MM. Henry que par le fac-simile reproduit dans l'*Astronomie* de M. Flammarion. Ce fac-simile contient, me semble-t-il, cinq petites étoiles entre les deux couples ϵ^1 et ϵ^2; ce sont les étoiles E, F, G, H, I de l'*Observatory*, no. 44, p. 638. Je suis étonné de ne pas y trouver les étoiles J et K que je vois également avec mon objectif de Grubb; celui-ci montre de cette façon toutes les étoiles vues dans cette région par le Rév. Dawes. M. Hall, à Washington, a vu également les étoiles E, F, G, H, I, J et, de plus, l'étoile L, de Lassell, l'étoile X de Pratt et une étoile nouvelle située au sud de J. F et G sont les *Debilissimæ* d'Herschel (*v.* 'Observatory,' no. 44, 54, 66). M. Pauwels, d'Aix-la-Chapelle, qui m'a fait le plaisir de venir observer dans mon équatorial le soir du 30 Septembre, a vu, entre autres choses, le groupe ϵ Lyræ et a reconnu les étoiles E, F, G, H; mais cette observation a été un peu trop rapide.

Veuillez, Messieurs, agréer l'expression des meilleurs sentiments de

Votre bien dévoué,

Louvain, le 1 novembre, 1886.

Dr. F. Terby.

31 *Messier Andromedæ.*

Gentlemen,—

As it would appear from some of the recent observations of 31 Messier Andromedæ made on the Continent and published in the 'Astronomische Nachrichten' that a change of some sort has taken place within the last two months, it would be interesting to know whether the nebula has been recently observed with a large aperture. My own results are of a purely negative character, as I

find by my notes that the appearance of the nebula on the 15th and 28th Sept. was quite normal; when next observed, on the 19th of Oct., the central part appeared bright; but this may have been due to the thick air which obliterated the fainter portions. On the 5th Nov., after the Moon had set, I examined it most carefully with powers ranging from 60 to 320 on my 10-inch reflector, but could trace no brighter point other than the usual nucleus, while the central condensation appeared much as usual. However, Mr. I. W. Ward at Belfast, found on 1st Nov. the nebula apparently much brighter than usual, as shown in his letter to the 'English Mechanic' of 5th Nov. There is not much doubt that there was a considerable increase in the brightness of the nebula prior to the appearance of the Nova in 1885; and I have several times noted apparent fluctuations in the light of the central part, although the absence of any well-defined standard of comparison must render any accurate estimate very difficult, and they are probably due to atmospheric causes. Possibly a larger aperture might show more; but the evidence of decided change seems, on the whole, rather unsatisfactory. The recent exceptionally unfavourable weather has prevented any further observations since the 5th inst.

Believe me, faithfully yours,
KENNETH J. TARRANT.

Letchford House, Pinner.
1886, Nov. 13.

A new Variable.

GENTLEMEN,—

I notice in the Oct. no. of the 'Observatory,' p. 334, a letter from Prof. R. L. J. Ellery, in which he mentions the probable discovery of a new variable in the constellation Lepus.

If Prof. Ellery had referred to Dr. Gould's 'Uranometria Argentina,' he could have identified the star as No. 38 (U. A.) Leporis = Ll. 10063 = R.A. $5^h\ 15^m\ 7^s$, Decl. −21° 27′·0 (1875·0), 4·9 mag. The star may possibly be variable, although observations made under the conditions mentioned by Prof. Ellery can hardly be considered to furnish evidence of variation. In connection with a work involving the careful intercomparison of the stars situated in this region of the heavens, I have on three occasions observed this star, and the determined magnitudes are as follows:—

Feb. 6, 1882 = 5·0 mag. Mar. 13, 1882 = 5·2 mag. Feb. 24, 1886 = 4·75 mag. Mean = 4·9 mag. These observations furnish but slight evidence of the star's variation in light.

Yours truly,
EDWIN F. SAWYER.

Cambridgeport, Mass., U. S. A.
Oct. 24, 1886.

NOTES.

THE DISTRIBUTION OF THE STARS in SCHÖNFELD'S 'DURCHMUSTERUNG'*.—In this paper Prof. Seeliger publishes the continuation of his researches on the subject of the distribution of the stars of the 'Bonner Durchmusterung'; a former contribution to this subject, referring to Argelander's observations, is noticed in the 'Observatory,' Vol. viii. p. 58. The paper now before us discusses in a similar manner the stars contained in Schönfeld's southern extension of the 'Durchmusterung,' which gives the places of stars down to mag. 10 situated between $-2°$ and $-23°$ of declination. The stars have been divided into eight classes, depending on magnitude. Class I. contains stars of mag. 1 to 6·5 inclusive; Class II. those of mag. 6·6 to 7·0; Class III. those of mag. 7·1 to 7·5; and so on down to Class VIII., which contains stars of mag. 9·6 to 10·0. The stars have then been counted in zones of declination 1° in width and in groups embracing 40 minutes of R.A. The sums of these counts for each of the above mentioned classes are:—Class I. 1265; Class II. 1276; Class III. 1828; Class IV. 3516; Class V. 7601; Class VI. 18633; Class VII. 55565; and Class VIII. 43896. The total number of stars thus counted is 133580, and adding to this 79 objects which are classed as nebulæ or variables, there results the grand total 133659. This agrees with the summation of the numbers given by Schönfeld in his work. In order to investigate the influence of the Milky Way on the distribution of these stars, Prof Seeliger proceeds as in the former paper, referred to above, to form the "gradient" for each class of stars, which expresses the rapidity of increase in the number of stars of each class as we approach the Milky Way. Comparing these values of the gradients with those found for Argelander's DM., it is seen that, at least for the first four classes, the former are decidedly smaller than the latter. If, then, we can assume the southern DM. to be typical of the whole southern hemisphere (remembering that it only embraces one-third thereof), it would appear that for this hemisphere the influence of the Milky Way is less marked than for the northern. But it may very well be that, especially in the higher classes of stars, local and accidental irregularities in stellar distribution may be the cause of this apparent difference in the two hemispheres. With regard to the question as to which hemisphere is the richer in stars, Prof. Seeliger finds that, for stars down to mag. 9, there is no very marked difference. When Argelander's numbers are corrected so as to be comparable with Schönfeld's, the totals are, for the former 34324, and for the latter 34119. But it is hardly safe to generalize for the whole southern hemisphere from observations extending over such a small portion of it, and we think that Prof. Seeliger would be doing good were he to discuss the Cordoba zones in the same thorough manner as he has done those observed at Bonn.

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* Separat-Abdruck aus den Sitzungsberichten der mathem.-phys. Classe der k. bayer. Akad. d. Wiss. 1886, Heft 2.

THE MASS OF MERCURY*.—M. O. Backlund, in the course of his researches on the motion of Encke's Comet during its apparitions in 1871, 1875, 1878, 1881, and 1885, has found that the comet approached Mercury sufficiently closely in August 1878 to enable him to make a new determination of the planet's mass from the perturbations caused by it in the motion of the comet about that time. The reciprocal of the mass of Mercury thus found is 2,668,700; which is the largest value of the mass of the planet hitherto determined. And M. Backlund states that, even supposing the acceleration of the comet's mean motion to be constant during the entire interval 1871–1885, it is impossible to represent satisfactorily the observations made during that time if the reciprocal of the mass of Mercury be taken to be greater than 5,000,000.

THE LEANDER M'CORMICK OBSERVATORY.—Prof. Ormond Stone, the Director of the Leander M'Cormick Observatory of the University of Virginia, has issued his report for the year ending June 1, 1886. The great 26-inch equatoreal has been chiefly employed in the examination and sketching of southern nebulæ. The nebula in Orion and the Trifid and Omega nebulæ have received special attention. During the year 233 nebulæ have been discovered which are supposed not to have been hitherto detected. Prof. Stone thinks that the performance of his refractor surpasses that of any of the great reflectors which have been used in the observation of nebulæ, the examination of complicated structures seldom failing to show features not noticed elsewhere. In addition to the above, 76 observations have been made of stellar pairs, nearly all of which are close and difficult. And observations of three comets, viz. Barnard's Comet 1885 II., Barnard's Comet of 1886, and Tuttle's periodic comet, have been secured. Several lunar occultations have also been observed and the paths of a number of meteors, principally telescopic, have been noted.

THE NATAL OBSERVATORY.—We have received Mr. Neison's Report, dated February 1, 1886, dealing with the work for the year 1885. Owing to some uncertainty as to the future status of the Institution, as well as to the prolonged illness of its head, the work of the Observatory has been seriously crippled during the year. Observing operations in the astronomical department have been almost entirely confined to routine work with the 3-inch transit. The number of observations made with this instrument during the year was 706, including 136 zenith-star observations for latitude. It is proposed to determine the latitude of the Observatory with the greatest care, as one of the primary points of the great geodetic survey of South Africa. Arrangements have also been made for comparing, by Talcott's method, the zenith-distances of a number of southern circumpolar stars with suitably placed northern stars of corresponding zenith-distance, with the view of better connecting the fundamental declinations determined at northern and southern observatories. A list of 32 stars has been prepared for this purpose. Other astronomical investigations carried on under Mr. Neison's direction at the Natal Observatory are the reduction of the observations of the lunar crater Murchison A, researches in the lunar theory, work connected with the time-signal service of the Colony, and the reduction of tidal observations made at Durban. We note with interest Mr. Neison's remark that it was found possible to make arrangements by which the services of four ladies were obtained as astronomical computers, and that, owing to their zealous work during the year, the Observatory has been able to carry out a great mass of difficult calculation.

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* Bulletin Astronomique, Tome iii. p. 473.

THE PULKOWA OBSERVATORY.—In his Report for the year ending May 25, 1886, M. Struve expresses his continued satisfaction at the performance of the great 30-inch refractor. A year's experience with it has demonstrated the great excellence of the mounting and of the optical qualities of the instrument. It has been employed during the year in the observation of the fainter double stars of Burnham's lists and the satellites of Mars, Saturn, and Neptune. The Maia nebula, which was discovered photographically at Paris, was first directly seen in the Pulkowa refractor. The observations with this instrument during the year were made by H. Struve. The 15-inch refractor has also been employed by the same observer. During the year he has obtained 42 measures of the position of Iapetus with respect to Titan, 40 of Titan with respect to Rhea, and 23 of Rhea with respect to Dione. With the 4-inch heliometer Backlund has measured 60 relative positions of Jupiter's satellites, and has also made a series of observations for determination of the parallax of Bradley 3077—a star with large proper motion. The meridian instruments, the great transit, the vertical circle, and the meridian-circle (in charge respectively of Wagner, Nyrén, and Romberg) have been actively employed during the year, the two former in determining the positions of the Pulkowa fundamental stars, and the latter in observing a miscellaneous list of stars with large proper motion, comet-stars, &c. By using a Steinheil objective of 50 mm. aperture and 1·5 m. focal length, in combination with two bisulphideof-carbon prisms, Hasselberg has succeeded in obtaining such excellent photographic images of the solar spectrum, that between wave-length 4000 and 4227 of Ångström's scale, where Vogel's map shows only 450 lines, he is able to count some 650. Hasselberg proposes, however, to postpone further investigation in this direction until the publication of the results of Rowland's researches of a similar character. During the course of the year to which the Report refers, 140 Sun pictures were taken on 110 days.

WATCH AND CLOCKMAKER'S HANDBOOK *.—This is the sixth and new edition of a book well known in the trade. The author being the Secretary to the Horological Institute enjoys great advantages in the compilation of such a work, and has indeed made the best use of his knowledge. The work is surprisingly free from "technicalities," and can be read with appreciation by "outsiders." Its arrangement in dictionary form makes it useful for reference to those who have but small acquaintance with clocks and watches. Altogether we can recommend it as certainly the most suitable book on the subject for astronomers that we have seen.

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10 SAGITTÆ.—Mr. S. C. Chandler finds from a discussion of observations made by Mr. Gore, himself, and at the Harvard and Oxford Observatories, the following formula for this star:—M. $=1885$, Dec. $4^{d}\ 9^{h}\ 36^{m}$, G.M.T. $+8^{d}\ 9^{h}\ 11^{m}{\cdot}0$ (E.-391), the duration of increase being $3^{d}{\cdot}00$ and of decrease $5^{d}{\cdot}38$, and the magnitude at maximum being 5·6 and at minimum 6·4.

GORE'S NOVA ORIONIS.—Recent observations of this star seem to prove that it is an ordinary variable with a period of about a year. According to Fr. Schwab it diminished in brightness throughout the first half of this year until the early part of July, when it was below the 12th magnitude. Since then it has increased again. Mr. Espin found it $9^{m}{\cdot}3$ on Sept. 14, $8^{m}{\cdot}5$ on Nov. 3, and M. Dunér gives the formula for its maximum as, 1885 Dec. $15+359^{d}{\cdot}5$. It should therefore be at its maximum about Dec. 10. Its spectrum still remains a fine example of Secchi's third type.

THE GREAT NEBULA IN ANDROMEDA.—In the 'Astronomische Nachrichten,' No. 2750, and in subsequent numbers, Herr v. Kövesligethy has drawn attention to certain changes in the Great Nebula of Andromeda as observed by Baron Podmaniczky at his private observatory at Kis Kartel. On Sept. 26 the nucleus was more intense than usual and another point of light appeared to the S.E.

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* The Watch and Clockmaker's Handbook, Dictionary, and Guide. By F. J. Britten. Published by Kent and Co., Paternoster Row, and E. and F. Spon, 35 Murray Street, New York.

of it. From this date this new spot of light became more star-like, and up to the evening of Oct. 2 both nucleus and new star were distinctly visible. From Oct. 2 to Oct. 17 the old nucleus was invisible. By Oct. 23 the nucleus had assumed its normal state, but the new star was not seen. Herr Lamp, who was at Kiel observing on some of the nights in question, is of opinion, on the other hand, that no real change has occurred.

THE TOTAL SOLAR ECLIPSE OF 1886, AUG. 29.—Prof. Tacchini gives a brief account of his observations of this eclipse in the 'Atti della Reale Accademia dei Lincei,' Series 4, vol. ii. fasc. 7. The most important part of the letter is occupied with his conclusions as to the prominences seen during totality and in full sunshine, which were given in the 'Observatory' for October, p. 342. Prof. Tacchini also notes his failure to see the lines in the spectra of the *panaches* which he had observed in 1883, but remarks that the *panaches* had a very different character on the two occasions, and that three years had elapsed since his previous observations, and he recommends that the search for the lines be undertaken in future eclipses. He also mentions that he noticed in the corona, amongst other things, a special and fairly luminous stratum in contact with the chromosphere, and that he found the inner corona different in structure to what it was in 1883. The darkness during the total phase was much greater than during the eclipse watched from Caroline Island.

NEW MINOR PLANETS.—Prof. Peters discovered a new minor planet, No. 261, on Oct. 31, and Herr Palisa two, both of the 12th magnitude, Nos. 262 and 263, on Nov. 3.

'GOULD'S ASTRONOMICAL JOURNAL' AND 'THE ASTRONOMICAL REGISTER.'—We have to record at the same time the fresh appearance of one astronomical review and the cessation of another—'Gould's Astronomical Journal' having appeared again on Nov. 2 after an interval of 25 years, and the present (December) number of the 'Astronomical Register' being the closing one of that publication. The high reputation 'Gould's Journal' won during its first period of existence will cause astronomers generally to cordially welcome its re-issue. The lifetime of the 'Register' almost exactly fills up the interval between the former and present series of 'Gould's Journal.' Although it would be affectation to ignore the fact that recently the 'Register' has not been equal to its earlier merit, it has had a long, honourable, and useful career, and has well fulfilled its part in the promotion of our science.

WE regret to note the death, on Nov. 14, of August Wagner, of the Pulkowa Observatory, in the 59th year of his age. Also of Maj.-General J. T. Boileau, R.E., F.R.S., who died Nov. 5, aged 81.

Elements and Ephemeris of Comet Finlay (1886 *e*)*.

By A. Krueger.

The following elements were calculated from observations ob at Rome on Sept. 29, Oct. 14, Oct. 23, and Nov. 1:—

T=1886 Nov. 22·23427, Berlin Mean Time.

π	9° 16′ 5″·1	Mean Eq. 1886·0.
ω	316 4 15·7	
☊	53 11 49·4	
i	2 59 24·6	
φ	44 12 23·2	
Log *a*	0·511116	
μ	607″·0970	

Ephemeris for Berlin Midnight.

1886.		R.A. h	m	s	Dec. °	′	Log *r*.	Log Δ.
Dec.	2..	21	21	12	−17	27·2	9·9971	9·9060
	6..	21	41	53	15	31·9	0·0016	9·8992
	10..	22	2	49	13	25·6	0·0074	9·8941
	14..	22	23	51	11	9·7	0·0142	9·8909
	18..	22	44	58	8	46·0	0·0221	9·8901
	22..	23	6	0	6	16·7	0·0309	9·8917
	26..	23	26	49	− 3	44·6	0·0404	9·8958

The brightness at the date of discovery is taken as unity.

Elements and Ephemeris of Comet Barnard (1886 *f*)†.

By A. Krueger and Aug. Svedstrup.

The following elements were calculated from observations ob at Copenhagen on Oct. 6, Palermo Oct. 13, Strassburg O and Kiel Oct. 29:—

T=1886 Dec. 16·496, Berlin Mean Time.

ω	86° 23′·6	Mean Eq. 1886·0.
☊	137 21·4	
i	101 41·5	
Log *q*	9·82118	

Ephemeris for Berlin Midnight.

1886.		R.A. h	m	s	Dec. °	′	Log *r*.	Log Δ.
Dec.	1..	15	15	46	+17	48·9	9·8652	9·9886
	6..	16	11	39	17	48·9	9·8420	9·9853
	11..	17	6	7	16	20·9	9·8266	0·0004
	16..	17	54	19	13	43·9	9·8212	0·0300
	21..	18	34	18	10	32·2	9·8266	0·0679
	26..	19	6	32	7	13·7	9·8421	0·1084
	31..	19	32	32	+ 4	5·2	9·8652	0·1478

The brightness at the date of discovery is taken as unity.

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* Astron. Nachr. No. 2755.

† Ibid. Nos. 2753 and 275

HE OBSERVATORY,

A

MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
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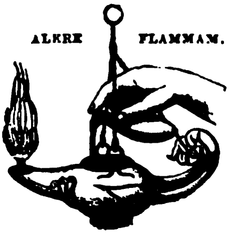
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Liverpool Astronomical Society Observatory, 172.
Loomis' 'Contributions to Meteorology,' 202.
Longitudes, Australian, 199.
Lunar Apsides, Motion, 143.
— Crater, Plato, 59, 345.
— Craters, Selenographical Longitudes and Latitudes of, 48.
'Lunar Science,' 196.
— Theory, Airy's, 174, 339, 377.
Luther, Dr. E., the late, 432.
Lynn, Alleged ancient red colour of Sirius, 104, 194.
—, Aratus and Hipparchus, 162.
—, First discovery of the Great Nebula in Orion, 232.
—, Montaigne's observation of a Satellite of Venus in 1761, 73.
—, Professor Rigaud, 71.
—, Suggested mean distances of ultra-Neptunian Planets, 318.
—, θ^1 and θ^2 Tauri, 367.
—, The Great Comet discovered by Montaigne and Olbers in 1780, 355.
—, The Comet of 1680 and its supposed previous appearance, 318.
—, The Great Comet of 1825, 232.
—, The orbits of Comets, 324.
—, The Rotation of Jupiter, 431.
—, The Variable Star Algol, 320.
—, Variability of η Aquilæ, 194.
Lynn's 'Celestial Motions,' 208.
Lyra, New Variable Star in the Ring Nebula in, 335.

Madras Observatory, 109, 276.
Magnitudes of Stars employed in Nautical Almanacs, 333.
Mars, Ephemeris for, 16.
Maunder, Bibliography of Astronomy, 421.
Melbourne Observatory, 237.
Mercury, Ephemeris for, 14.
Meteor Notes, 2-13, 65, 102, 129, 159, 188, 227, 265, 299, 313, 351, 384, 417.
Meteorites, Researches on the Spectra of, 429.
Meteor-paths, determination of, 358.
Meteors, Two fine, 107.
Meudon Observatory, 332.
Minor Planet Orbits, inclinations and eccentricities of, 278.
— Planets and Comets, 173, 230.
— —, Names of, 80, 143, 175, 203, 368, 439.
— —, New, 112, 174, 240, 280, 368, 400.
Monck, Brightness and masses of Binary Stars, 96.
Monck, Colours of Stars and Solar Heat, 164.
——, Comets and Asteroids, [illegible]
——, Further Notes on Binary Stars, 124.
——, Gore's Nova Orionis, 69.
——, Orbits of Comets, 324.
——, The periods of the Planets, 322, 425.
——, Variable Star Algol, 320, 425.
Morrison Observatory, 365.

Natal Observatory, 436.
Neptune, Ephemeris for, 17.
——, Ephemeris for Satellite of, [illegible]
New Observatory at Juvisy, 364.
Nice Observatory, 362.
Noble, The Length of the Saros, 425.
Noble's 'Hours with a Three-inch Telescope,' 111.
Notes:—74-80, 108-112, 140-142, 166-175, 196-208, 234-240, 275-280, 304-308, 325-326, 363-368, 395-400, 425-432.
Nova Orionis, 69.
Nutation of the Earth's Axis, Diurnal, 75.

Observatories, American, [illegible]
——, Continental, 304.
Observatory, Bamberg, 272.
——, Berlin, 304.
——, Bonn, 304.
——, Brussels, 304.
——, Dearborn, 398.
——, Dresden, 304.
——, Düsseldorf, 304.
——, Engelhardt, 197.
——, Geneva, 305.
——, Gotha, 305.
——, Greenwich, 277.
——, Harvard College, 76, 169, 197, 234.
——, Herény (Hungary), 305.
——, Hong Kong, 230.
——, Kalocsa, 77, 78.
——, Kiel, 305.
——, Leander McCormick, 365.
——, Leipzig, 305.
——, Lick, 110, 168.
——, Liverpool Astronomical Society, 172.
——, Lund, 305.
——, Madras, 109, 276.
——, Melbourne, 237.
——, Meudon, 332.
——, Milan, 305.
——, Morrison, 365.
——, Munich, 305.
——, Natal, 436.
——, New, at J

Observatory, Nice, 362.
——, O'Gyalla, 305.
——, Oxford University, 307.
——, Palermo, 305.
——, Paris, 110, 205, 280.
——, Potsdam, 305.
——, Prague, 306.
——, Pulkowa, 396.
——, Rousdon, 169.
——, Temple, 142.
——, Warner, 172.
——, Washburn, 397.
——, Washington, 109.
Occultations in 1887, 19.
—— of Hyades, 195.
U Ophiuchi, 435.
Oppenheim, H., Elements and Ephemeris of Comet 1887 *b*, 143.
——, Elements and Ephemeris of Comet 1887 *c*, 144.
——, Elements and Ephemeris of Comet 1887 *e*, 240.
Oppolzer, Prof., the late, 80, 108, 309.
Oppolzer's 'Canon der Finsternisse,' 302.
Orion, First discovery of the Great Nebula in, 232.
——, Trapezium of, 136.
Oxford University Observatory, 307.
—— Uranometria, 362.
Oxygen and Carbon, Spectra of, compared with that of the Sun, 434.

P*alisa*, Elements for Comet 1887 *d*, 176.
Parallax Observations for Stellar, 137, 142, 167.
—— of Σ 1516, 202.
—— of α Tauri, 307.
—— of Σ 2398, 433.
Paris Observatory, 110, 205, 280.
Perry, The Chromosphere in 1886, 129.
Photographic Study of Stellar Spectra, 234.
Photographs, Examination of Stellar, 196, 231.
Photography and 42 M, 99.
—— and the determination of Stellar Parallax, 137, 167.
——, Astronomical, 239.
——, ——, at the Paris Observatory, 205.
—— in Astronomy, Applications of, 267, 283.
——, International Astronomical Congress on, 190.
——, Stellar, at Harvard College, 76.
Photometer, The Wedge, 362, 389.
Pickering, Proposed Index to Observations of Variable Stars, 301.
Planets, Periods of, 322, 391, 425.
Planets, suggested Mean Distances of Ultra-Neptunian, 318.
Plato, the Lunar Crater, in 1882–84, 59, 345.
'Pneumatics,' 331.
Polar Star Places, Close Reduction of, 170.
Porter, Variable Star Lalande 10063, 233.
Pritchard, Photography and the determination of Stellar Parallax, 137.
Proper Motion of Lal. 26481, 360, 428.
—— —— of θ' and θ^2 Tauri, 367.
Proper Motions of Stars, 437.
Pulkowa Observatory, 396.

R*adau*, Airy's Numerical Lunar Theory, 339, 377.
Ranyard, Photography and the Determination of Stellar Parallax, 167.
Red Star, New, 175.
—— Stars, Sweeping for, 258.
Refraction Tables, Correction for Gravity in, 79.
Rejection of Discordant Observations, 414.
Rendall, Noises accompanying Auroræ, 303.
Rigaud, Prof., 71.
Right Ascensions of certain Fundamental Stars, 204.
Rousdon Observatory, 169.
ROYAL ASTRONOMICAL SOCIETY, Meetings of, 49, 81, 113, 145, 177, 209, 241, 401.
—— —— ——, The Council of, 437.
Russell, Observations of Comet 1886 *e*, 294.

S*adler*, Achernar, 334.
Safford, Lalande 26481, 428.
Saros, The length of the, 423.
Saturn, 107, 136, 163.
——, Ephemeris for, 16.
——, Micrometer measures of, 239.
——, Ring, the inner dark, 161.
——, ——, Outer, Encke's division, 139.
——, Rings, Present Aspect of, 105, 231.
——, Satellites, Ephemeris for, 28–32.
——, ——, The Six Inner, 140.
Schjellerup, Dr., the late, 438.
Selenographical Longitudes and Latitudes of Lunar Craters, 48.
SELENOGRAPHICAL NOTES, 67, 100, 127, 157, 187, 226, 263, 298, 316, 354, 386, 419.
Sirius, Alleged ancient red colour of, 104, 194.
——, Companion of, 136, 163, 263.

Liverpool Astronomical Society Observatory, 172.
Loomis' 'Contributions to Meteorology,' 302.
Longitudes, Australian, 199.
Lunar Apsides, Motion, 143.
— Crater, Plato, 59, 345.
— Craters, Selenographical Longitudes and Latitudes of, 48.
'Lunar Science,' 196.
— Theory, Airy's, 174, 339, 377.
Luther, Dr. E., the late, 432.
Lynn, Alleged ancient red colour of Sirius, 104, 194.
—, Aratus and Hipparchus, 162.
—, First discovery of the Great Nebula in Orion, 232.
—, Montaigne's observation of a satellite of Venus in 1761, 73.
—, Professor Rigaud, 71.
—, Suggested mean distances of ultra-Neptunian Planets, 318.
—, θ^1 and θ^2 Tauri, 367.
—, The Great Comet discovered by Montaigne and Olbers in 1780, 355.
—, The Comet of 1680 and its supposed previous appearance, 318.
—, The Great Comet of 1825, 232.
—, The orbits of Comets, 324.
—, The Rotation of Jupiter, 431.
—, The Variable Star Algol, 320.
—, Variability of ϵ Aquilæ, 194.
Lynn's 'Celestial Motions,' 208.
Lyra, New Variable Star in the Ring Nebula in, 335.

Madras Observatory, 109, 276.
Magnitudes of Stars employed in Nautical Almanacs, 333.
Mars, Ephemeris for, 16.
Maunder, Bibliography of Astronomy, 421.
Melbourne Observatory, 237.
Mercury, Ephemeris for, 14.
Meteor Notes, 2–13, 65, 102, 129, 159, 188, 227, 265, 299, 313, 351, 384, 417.
Meteorites, Researches on the Spectra of, 429.
Meteor-paths, determination of, 358.
Meteors, Two fine, 107.
Meudon Observatory, 332.
Minor Planet Orbits, inclinations and eccentricities of, 278.
— Planets and Comets, 173, 230.
— —, Names of, 80, 143, 175, 203, 368, 439.
— —, New, 112, 174, 240, 280, 368, 400.
Monck, Brightness and masses of Binary Stars, 96.
Monck, Colours of Stars and Solar Heat, 164.
—, Comets and Asteroids, 230.
—, Further Notes on Binary Stars, 134.
—, Gore's Nova Orionis, 69.
—, Orbits of Comets, 324.
—, The periods of the Planets, 322, 425.
—, Variable Star Algol, 357, 425.
Morrison Observatory, 365.

Natal Observatory, 436.
Neptune, Ephemeris for, 17.
—, Ephemeris for Satellite of, 34.
New Observatory at Juvisy, 364.
Nice Observatory, 362.
Noble, The Length of the Saros, 423.
Noble's 'Hours with a Three-inch Telescope,' 111.
NOTES:—74–80, 108–112, 140–143, 168–175, 196–208, 234–240, 276–280, 304–308, 326–336, 361–368, 395–400, 429–439.
Nova Orionis, 69.
Nutation of the Earth's Axis, Diurnal 75.

Observatories, American, 431.
—, Continental, 304.
Observatory, Bamberg, 279.
—, Berlin, 304.
—, Bonn, 304.
—, Brussels, 304.
—, Dearborn, 398.
—, Dresden, 304.
—, Düsseldorf, 304.
—, Engelhardt, 197.
—, Geneva, 305.
—, Gotha, 305.
—, Greenwich, 277.
—, Harvard College, 76, 169, 197, 234.
—, Herény (Hungary), 305.
—, Hong Kong, 239.
—, Kalocsa, 77, 78.
—, Kiel, 305.
—, Leander McCormick, 365.
—, Leipzig, 305.
—, Lick, 110, 168.
—, Liverpool Astronomical Society, 172.
—, Lund, 305.
—, Madras, 109, 276.
—, Melbourne, 237.
—, Meudon, 332.
—, Milan, 305.
—, Morrison, 365.
—, Munich, 305.
—, Natal, 436.
—, New, at Juvisy, 364.

ENGRAVINGS.

Page

Apparent Orbits of the Seven Inner Satellites of Saturn 28

Apparent Orbit of Iapetus 32

Apparent Orbits of the Satellites of Uranus 33

Apparent Orbit of the Satellite of Neptune 34

Diagram to explain variability of long period variables 70

Saturn.. 164

Plato, Second Period 347

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COMPANION
TO
HE OBSERVATORY,
A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
lation........ 1
dar, including **Rising** and Setting of the Sun and Moon, Longitude of
Moon's **Terminator, and** Meteor Notes........ 2–13
eris for **Mercury** 14
eris for **Venus** 15
eris for **Mars** 16
eris for **Jupiter** 16
eris for **Saturn**........ 16
eris for **Uranus** 17
eris for **Neptune** 17
s in 1887........ 17, 18
tions 19–21
ena of **Jupiter's Satellites,** 1887........ 22–27
eris for **Satellites of Saturn** 28–32
eris for **Satellites of Uranus**........ 33, 34
eris for **Satellite of Neptune** 34
eris for **Physical Observations of the Sun** 35
eris for **Physical Observations of Jupiter** 36–37
with **Remarkable Spectra** 37, 38
Places of **Variable Stars** for 1887·0 39
a and **Minima of Variable Stars** 40, 41
a of **Variable Stars of** the Algol type 42–44
a of **Variable Stars of** Short Period not of the Algol type 45, 46
Stars 46, 47
graphical **Longitudes** and Latitudes of Lunar Craters 48

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and T. LEWIS, F.R.A.S.

Contains full Reports of the Meetings of the Royal and Liverpool Astronomical Societies; Articles by various eminent Astronomers, English, American, and Continental; Correspondence on topics of interest connected with the Science; Notes on the progress of Astronomy; Reviews of astronomical publications; Ephemerides of comets, variable stars, Saturn's satellites, and for physical observations of the Sun, Jupiter, &c.; and all the usual astronomical information.

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CONTENTS OF No. 117.

PAGE

Titlepage and Index to Vol. IX.

Meeting of the Royal Astronomical Society on November 12 373

Meeting of the Liverpool Astronomical Society 385

Articles:—

Popular Fallacies about Observatories. By Miss MARY E. BYRD 389

Meteor Notes. By W. F. DENNING, F.R.A.S. 392

Photographing the Corona without an Eclipse. By E. L. TROUVELOT 394

Correspondence:—

The Pleiades and ϵ Lyræ. By Dr. F. TERBY, F.R.A.S. 396

31 Messier Andromedæ. By KENNETH J. TARRANT, F.R.A.S. 397

A new Variable. By EDWIN F. SAWYER 398

Notes:—

The Distribution of the Stars in Schönfeld's 'Durchmusterung.'—The Mass of Mercury.—The Leander M'Cormick Observatory.—The Natal Observatory.—The Pulkowa Observatory.—Watch and Clockmaker's Handbook.—10 Sagittæ.—Gore's Nova Orionis.—The Great Nebula in Andromeda.—The Total Solar Eclipse 1886, Aug. 29.—New Minor Planets.—'Gould's Astronomical Journal' and 'The Astronomical Register.'—Editorial Note 399-403

Elements and Ephemeris of Comet Finlay (1886 *e*). By Dr. A. KRUEGER 404

Elements and Ephemeris of Comet Barnard (1886 *f*). By Drs. A. KRUEGER and AUG. SVEDSTRUP 404

ANNUAL COMPANION

TO

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 118. 1887. Vol. X.

INTRODUCTION.

The Editors of the 'Observatory,' in bringing out a second 'Annual Companion,' would take the opportunity of thanking the many friends who wrote to express their satisfaction with the first issue. Two changes only were recommended: the first that all the phenomena of Jupiter's satellites, and not merely the eclipses, should be given; the second, that the longitude of the Moon's terminator should be supplied for each day. Both these recommendations have been followed, and a list of the coordinates of about one hundred of the principal lunar formations has also been added. In other respects the plan of the present 'Companion' resembles that of its predecessor, except that the short lists of "Remarkable Nebulæ" and "Noteworthy Double Stars" have been omitted, as there seemed no sufficient reason for reprinting them.

The principal sources from whence the Ephemerides have been derived are the same as last year. The Meteor Notes we owe to the kindness of Mr. Denning, the Catalogue and Ephemerides of Variable Stars to the ready courtesy of M. Loewy who forwarded to us advance sheets of that part of the forthcoming 'Annuaire du Bureau des Longitudes.' The Ephemeris for the Red Spot on Jupiter has been calculated from observations supplied by Mr. Denning; the phenomena of Jupiter's Satellites and the elements of occultations are extracted from the English 'Nautical Almanac,' the ephemerides of the Satellites of Saturn, Uranus, and Neptune from the 'American Nautical Almanac,' and the positions of Lunar Craters from Mr. Neison's 'Moon.' The latest published observations have been incorporated in the list of Binary Stars.

The "Fraction of the Year" is the fraction of the year which has elapsed at mean noon of the particular day. The "Longitude of the Moon's Terminator" is given for mean midnight; the letters M. and E. signify morning and evening—that is, that the Sun is rising or setting on that particular longitude of the Moon's surface; the sign − indicates longitudes reckoned from the central meridian in a westward direction, the sign + in an eastward. An innovation has been introduced in the section of occultations, in that the angles of disappearance and reappearance are given from the *true* north, and are reckoned in the direction N. E. S. W., as in double-star observations, instead of in the manner employed in the 'Nautical Almanac.'

Greenwich Mean Time is used in all cases, and the astronomical y is reckoned *from noon to noon* as in previous years.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Si Ti M N
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h
1	1	S	·000	4 0	20 8	11 35	5 30	+ 2·6 M.	0 3 47	18
2	2	**S**	·003	4 1	20 8	12 38	6 12	− 9·5 M.	4 15	
3	3	M	·006	4 2	20 8	13 43	6 55	−21·7 M.	4 43	
4	4	Tu	·008	4 3	20 8	14 50	7 40	−33·8 M.	5 10	
5	5	W	·011	4 4	20 7	15 57	8 28	−46·0 M.	5 37	18
6	6	Th	·014	4 6	20 7	17 4	9 19	−58·2 M.	6 4	19
7	7	F	·016	4 7	20 6	18 10	10 13	−70·3 M.	6 30	
8	8	S	·019	4 8	20 6	19 11	11 11	−82·5 M.	6 55	
9	9	**S**	·022	4 9	20 5	rises	12 9	......	7 20	
10	10	M	·025	4 10	20 5	5 18	13 9	+73·2 E.	7 45	
11	11	Tu	·027	4 12	20 4	6 33	14 7	+61·0 E.	8 9	
12	12	W	·030	4 14	20 3	7 52	15 3	+48·9 E.	8 32	
13	13	Th	·033	4 15	20 2	9 11	15 57	+36·7 E.	8 55	
14	14	F	·036	4 17	20 1	10 30	16 50	+24·6 E.	9 17	
15	15	S	·038	4 19	20 0	11 47	17 41	+12·4 E.	9 38	
16	16	**S**	·041	4 20	19 59	13 2	18 32	+ 0·2 E.	9 59	
17	17	M	·044	4 21	19 58	14 15	19 23	−12·0 E.	10 19	
18	18	Tu	·047	4 23	19 57	15 25	20 14	−24·1 E.	10 38	
19	19	W	·049	4 24	19 56	16 32	21 6	−36·3 E.	10 57	
20	20	Th	·052	4 26	19 55	17 33	21 58	−48·4 E.	11 15	19
21	21	F	·055	4 28	19 54	18 27	22 49	−60·6 E.	11 32	20
22	22	S	·058	4 30	19 53	19 13	23 40	−72·7 E.	11 49	
23	23	**S**	·060	4 32	19 52	sets	......	......	12 4	
24	24	M	·063	4 33	19 51	5 11	0 29	+82·8 M.	12 19	
25	25	Tu	·066	4 34	19 50	6 13	1 15	+70·7 M.	12 34	
26	26	W	·068	4 36	19 49	7 16	2 0	+58·6 M.	12 47	
27	27	Th	·071	4 38	19 48	8 19	2 44	+46·5 M.	12 59	
28	28	F	·074	4 40	19 46	9 22	3 26	+34·3 M.	13 11	
29	29	S	·077	4 42	19 45	10 25	4 8	+22·2 M.	13 22	
30	30	**S**	·079	4 44	19 43	11 28	4 50	+10·0 M.	13 32	
31	31	M	·082	4 46	19 41	12 32	5 34	− 2·1 M.	0 13 41	20

	d	h	m		d	h	m		d	h
First Quarter	2	0	21	Full Moon	9	10	32	First Quarter	31	20
Last Quarter	16	3	22	New Moon	23	15	1			

Meteor Notes.

There are a considerable number of showers visible during this month, t most important being the *Quadrantids*, R.A. 228°, Decl. +53°. The princi days on which the large meteors, commonly called fireballs, may be expected Jan. 2, 15, 16, 17, and 28.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Rema
	°	°			°	°	
Jan. 9–19	72	+ 4	W. of γ Orionis.	Jan. 1–25	181	+35	Swift; str
Jan. 2–4.........	119	+16	Swift; bright.	Jan. 4–11	220	+13	V. swift;
Jan. 1–Feb. 6...	133	+48	Near ι Urs. Maj.	Jan. 1–15	221	+42	V. swift;
Jan. 2–5.........	140	+57	V. swift; short.	Jan. 1–3.........	228	+53	Swift; lon
Jan.–Feb.	167	+ 5	Very swift.	January 28 ...	236	+25	V. swift;
January 11......	173	+ 9	Swift; streaks.	Jan. 14–17......	295	+53	Slowish, t

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h m s
32	1	Tu	·085	4 48	19 40	13 38	6 19	−14·3 M.	0 13 49	20 45 30
33	2	W	·088	4 49	19 38	14 44	7 7	−26·5 M.	13 57	49 27
34	3	Th	·090	4 50	19 36	15 49	7 58	−38·6 M.	14 4	50 23
35	4	F	·093	4 52	19 34	16 51	8 53	−50·8 M.	14 9	20 57 20
36	5	S	·096	4 54	19 32	17 48	9 50	−62·9 M.	14 14	21 1 17
37	6	**S**	·099	4 56	19 30	18 39	10 49	−75·1 M.	14 19	5 13
38	7	M	·101	4 57	19 29	rises	11 49	......	14 22	9 10
39	8	Tu	·104	4 59	19 27	5 23	12 48	+80·6 E.	14 24	13 6
40	9	W	·107	5 0	19 25	6 45	13 45	+68·5 E.	14 26	17 3
41	10	Th	·110	5 2	19 24	8 7	14 40	+56·3 E.	14 27	20 59
42	11	F	·112	5 4	19 22	9 28	15 34	+44·2 E.	14 27	24 56
43	12	S	·115	5 6	19 20	10 47	16 27	+32·0 E.	14 27	28 52
44	13	**S**	·118	5 8	19 18	12 4	17 19	+19·8 E.	14 25	32 49
45	14	M	·121	5 10	19 16	13 17	18 11	+ 7·6 E.	14 23	36 46
46	15	Tu	·123	5 12	19 14	14 26	19 3	− 4·6 E.	14 21	40 42
47	16	W	·126	5 14	19 12	15 28	19 55	−16·8 E.	14 17	44 39
48	17	Th	·129	5 16	19 10	16 23	20 46	−29·0 E.	14 13	48 35
49	18	F	·131	5 18	19 8	17 11	21 36	−41·2 E.	14 8	52 32
50	19	S	·134	5 19	19 7	17 52	22 25	−53·4 E.	14 3	21 56 28
51	20	**S**	·137	5 21	19 5	18 26	23 12	−65·5 E.	13 57	22 0 25
52	21	M	·140	5 23	19 3	18 55	23 57	−77·6 E.	13 50	4 21
53	22	Tu	·142	5 25	19 1	sets	......	......	13 42	8 18
54	23	W	·145	5 27	18 59	6 9	0 41	+78·1 M.	13 34	12 15
55	24	Th	·148	5 29	18 56	7 12	1 24	+66·0 M.	13 26	16 11
56	25	F	·151	5 30	18 54	8 16	2 6	+53·8 M.	13 16	20 8
57	26	S	·153	5 32	18 52	9 19	2 48	+41·6 M.	13 6	24 4
58	27	**S**	·156	5 34	18 50	10 22	3 30	+29·5 M.	12 56	28 1
59	28	M	·159	5 36	18 48	11 26	4 14	+17·3 M.	0 12 45	22 31 57

	d	h	m
Full Moon	7	22	14
Last Quarter	14	13	32
New Moon	22	9	40

Meteor Notes.

There are no periodical showers of the first order this month. The principal fireball dates are Feb. 2, 10, and 19.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
Feb. 23–25	30	+35	Near β Trianguli.	February	236	+11	Swift ; streaks.
Feb. 5–10	74	+43	Near α Aurigæ.	Feb. 17	237	+46	Near υ Herculis.
February	111	+62	Slow ; yellow.	Feb. 6	240	+62	Near θ–77 Draconis.
February	120	− 5	Slow ; yellow.				
Feb. 5–16	165	+73	Near λ Draconis.	Feb. 13–20	260	+ 2	V. swift; streaks.
				Feb. 20	263	+36	Rather swift.
Feb. 20	181	+34	V. swift ; white.	Feb. 10–Mar. 7.	280	−17	V. swift; streaks.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sidere Time Mea Noo
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h m
60	1	Tu	·162	5 37	18 46	12 30	5 0	+ 5·1 M.	0 12 33	22 35
61	2	W	·164	5 39	18 44	13 34	5 49	− 7·1 M.	12 21	39
62	3	Th	·167	5 41	18 42	14 36	6 40	−19·2 M.	12 9	43
63	4	F	·170	5 43	18 40	15 34	7 34	−31·4 M.	11 56	47
64	5	S	·173	5 45	18 38	16 26	8 31	−43·6 M.	11 42	51
65	6	**S**	·175	5 46	18 36	17 11	9 29	−65·8 M.	11 28	55
66	7	M	·178	5 48	18 34	17 50	10 27	−78·0 M.	11 14	22 59
67	8	Tu	·181	5 50	18 21	18 24	11 25	−80·2 M.	10 59	23 3
68	9	W	·183	5 51	18 28	rises	12 22	……	10 44	7
69	10	Th	·186	5 53	18 26	6 59	13 18	+75·5 E.	10 28	11
70	11	F	·189	5 55	18 23	8 22	14 14	+63·3 E.	10 12	15
71	12	S	·192	5 57	18 21	9 43	15 8	+51·2 E.	9 56	19
72	13	**S**	·194	5 58	18 18	11 0	16 2	+39·0 E.	9 39	23
73	14	M	·197	6 0	18 16	12 13	16 56	+26·8 E.	9 23	27
74	15	Tu	·200	6 2	18 13	13 20	17 50	+14·6 E.	9 6	31
75	16	W	·203	6 4	18 11	14 19	18 42	+ 2·4 E.	8 48	35
76	17	Th	·205	6 6	18 9	15 10	19 33	− 9·8 E.	8 31	38
77	18	F	·208	6 8	18 7	15 53	20 22	−22·0 E.	8 13	42
78	19	S	·211	6 10	18 5	16 29	21 10	−34·1 E.	7 56	46
79	20	**S**	·214	6 11	18 3	16 59	21 55	−46·3 E.	7 38	50
80	21	M	·216	6 12	18 1	17 25	22 39	−58·5 E.	7 20	54
81	22	Tu	·219	6 14	17 59	17 49	23 22	−70·7 E.	7 2	23 58
82	23	W	·222	6 15	17 57	18 12	……	−82·9 E.	6 43	0 2
83	24	Th	·225	6 17	17 54	sets	0 4	……	6 25	6
84	25	F	·227	6 18	17 52	7 11	0 46	+72·7 M.	6 7	10
85	26	S	·230	6 20	17 50	8 15	1 29	+60·5 M.	5 48	14
86	27	**S**	·233	6 22	17 48	9 19	2 12	+48·4 M.	5 30	18
87	28	M	·236	6 24	17 45	10 22	2 58	+36·2 M.	5 12	22
88	29	Tu	·238	6 26	17 43	11 26	3 45	+24·0 M.	4 53	26
89	30	W	·241	6 28	17 41	12 28	4 34	+11·8 M.	4 35	30
90	31	Th	·244	6 30	17 38	13 26	5 26	− 0·4 M.	0 4 17	0 34

	d	h	m		d	h	m
First Quarter	2	13	8	Full Moon	9	8	34
Last Quarter	16	1	42	New Moon	24	4	10

Meteor Notes.

The most favourable nights for meteor-observations are March 1–4 and 7. Fireballs should be looked for March 1–4, 5–10, and 18.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remark
	°	°			°	°	
Mar. 1–15 ……	50	+48	Near α Aurigæ.	Mar. 2–3 ……	193	+ 1	Near δ Vir
Mar. 9–27 ……	98	+46	Near 55 Aurigæ.	Mar. 7 ………	233	−18	Very swift.
Mar. 20 ………	144	+48	Near θ Ursæ Maj.	Mar. 7 ………	244	+15	Very swift.
Mar. 3–15 ……	175	+10	Slow ; brilliant.	March ………	263	+48	Near β Dra
Mar. 17 ………	186	+56	Swift.	Mar. 14–15 …	276	+ 6	Very swift.
Mar. 8 ………	189	+26	From Coma Berenices.	Mar. 1–15 ……	300	+80	Slow ; brill

Week.	Fraction of year.	Sun. Sets.	Sun. Rises.	Moon. Sets.	Moon. Souths.	Moon. Long. of Terminator.	Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
		h m	h m	h m	h m	°	h m s	h m s
F	·246	6 31	17 36	14 18	6 20	−12·6 M.	0 3 59	0 38 7
S	·249	6 33	17 34	15 4	7 16	−24·8 M.	3 41	42 3
S	·252	6 35	17 32	15 44	8 12	−37·0 M.	3 23	46 0
M	·255	6 37	17 29	16 19	9 8	−49·2 M.	3 5	49 57
Tu	·257	6 38	17 27	16 51	10 4	−61·4 M.	2 47	53 53
W	·260	6 40	17 24	17 20	11 0	−73·6 M.	2 30	0 57 50
Th	·263	6 41	17 22	rises	11 55	……	2 12	1 1 46
F	·266	6 43	17 20	7 11	12 51	+82·1 E.	1 55	5 43
S	·268	6 44	17 18	8 33	13 47	+69·9 E.	1 38	9 39
S	·271	6 45	17 15	9 51	14 43	+57·7 E.	1 21	13 36
M	·274	6 46	17 13	11 4	15 39	+45·5 E.	1 5	17 32
Tu	·277	6 48	17 11	12 9	16 33	+33·3 E.	0 49	21 29
W	·279	6 50	17 9	13 5	17 27	+21·1 E.	0 33	25 26
Th	·282	6 52	17 7	13 52	18 18	+ 8·9 E.	0 18	29 22
F	·285	6 53	17 5	14 30	19 6	− 3·3 E.	0 0 3	33 19
S	·288	6 55	17 2	15 3	19 53	−15·5 E.	23 59 48	37 15
S	·290	6 57	17 0	15 31	20 38	−27·7 E.	59 34	41 12
M	·293	6 59	16 58	15 55	21 21	−39·9 E.	59 20	45 8
Tu	·296	7 0	16 56	16 17	22 3	−52·1 E.	59 6	49 5
W	·298	7 2	16 55	16 38	22 45	−64·3 E.	58 53	53 1
Th	·301	7 4	16 53	17 0	23 27	−76·5 E.	58 41	1 56 58
F	·304	7 6	16 51	sets	……	……	58 29	2 0 55
S	·307	7 8	16 49	7 10	0 11	+79·0 M.	58 17	4 51
S	·309	7 10	16 47	8 15	0 56	+66·8 M.	58 6	8 48
M	·312	7 11	16 45	9 20	1 43	+54·6 M.	57 55	12 44
Tu	·315	7 13	16 43	10 23	2 32	+42·4 M.	57 44	16 41
W	·318	7 14	16 41	11 22	3 23	+30·2 M.	57 35	20 37
Th	·320	7 16	16 39	12 16	4 16	+18·0 M.	57 25	24 34
F	·323	7 17	16 37	13 4	5 10	+ 5·8 M.	57 16	28 30
S	·326	7 19	16 35	13 45	6 4	− 6·4 M.	23 57 8	2 32 27

	d	h	m		d	h	m		d	h	m
Quarter	1	1	53	**Full Moon**	7	17	39	**First Quarter**	30	11	0
Quarter	14	16	4	**New Moon**	22	20	53				

Meteor Notes.

ere are several good showers which may usually be expected this month. *yrids* form the most interesting. The chief fireball dates are April 2, 6, , and 25–30. The latter at 269° +33°.

on.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
2 ……	162	+59	Near β Ursæ Maj.	April 9–12 ……	249	+51	Near δ Virginis.
……	174	+ 7	Slow ; bright.	April 9–26 ……	255	+37	Very swift.
y……	208	+58	Slow ; bright.	April 19–20 …	269	+33	Very swift.
y……	228	− 4	Rather slow.	April 13–20 …	270	+25	Near β Draconis.
26 …	213	+ 9	Very slow.	April 19–20 …	299	+24	Very swift.
May 5	234	+10	Swift.	April 1–12 ……	304	+12	Slow ; brilliant.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	S Ti
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h
121	1	**S**	·329	7 21	16 33	14 20	6 59	−18·6 M.	23 57 0	2
122	2	M	·331	7 23	16 31	14 51	7 53	−30·8 M.	56 53	
123	3	Tu	·334	7 24	16 29	15 20	8 47	−43·0 M.	56 46	
124	4	W	·337	7 26	16 28	15 47	9 40	−55·2 M.	56 40	
125	5	Th	·340	7 27	16 26	16 15	10 35	−67·4 M.	56 34	
126	6	F	·342	7 29	16 24	16 45	11 30	−79·6 M.	56 29	2
127	7	S	·345	7 30	16 22	rises	12 26	……	56 24	3
128	8	**S**	·348	7 31	16 21	8 41	13 22	+75·9 E.	56 20	
129	9	M	·350	7 33	16 19	9 52	14 19	+63·7 E.	56 17	
130	10	Tu	·353	7 34	16 17	10 54	15 15	+51·5 E.	56 14	
131	11	W	·356	7 36	16 15	11 46	16 8	+39·3 E.	56 11	
132	12	Th	·359	7 38	16 14	12 30	17 0	+27·1 E.	56 10	
133	13	F	·361	7 39	16 12	13 5	17 48	+14·9 E.	56 9	
134	14	S	·364	7 41	16 11	13 34	18 34	+ 2·7 E.	56 8	
135	15	**S**	·367	7 42	16 10	14 0	19 18	− 9·5 E.	56 8	
136	16	M	·370	7 44	16 8	14 23	20 0	−21·7 E.	56 9	
137	17	Tu	·372	7 45	16 6	14 44	20 42	−33·9 E.	56 10	
138	18	W	·375	7 47	16 5	15 5	21 24	−46·1 E.	56 12	
139	19	Th	·378	7 48	16 4	15 27	22 7	−58·3 E.	56 14	
140	20	F	·381	7 49	16 3	15 50	22 52	−70·5 E.	56 17	
141	21	S	·383	7 50	16 2	16 17	23 38	−82·8 E.	56 21	
142	22	**S**	·386	7 51	16 0	sets	……	……	56 25	3
143	23	M	·389	7 53	15 59	8 15	0 27	+72·8 M.	56 29	4
144	24	Tu	·392	7 55	15 58	9 17	1 19	+60·6 M.	56 34	
145	25	W	·394	7 57	15 57	10 14	2 12	+48·4 M.	56 40	
146	26	Th	·397	7 58	15 56	11 5	3 6	+36·2 M.	56 46	
147	27	F	·400	7 59	15 55	11 48	4 1	+24·0 M.	56 52	
148	28	S	·403	8 0	15 54	12 24	4 55	+11·8 M.	56 59	
149	29	**S**	·405	8 1	15 53	12 55	5 49	− 0·4 M.	57 7	
150	30	M	·408	8 2	15 52	13 23	6 41	−12·7 M.	57 15	
151	31	Tu	·411	8 3	15 51	13 50	7 33	−24·9 M.	23 57 23	4

	d	h	m		d	h	m
Full Moon	7	2	1	Last Quarter	14	8	17
New Moon	22	11	5	First Quarter	29	17	20

Meteor Notes.

There are no great periodical showers in this month. Fireball date May 1, 13, 20, 21, and 31.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Rem
	°	°			°	°	
May 3–15 ……	170	−10	Very slow.	May 15 ………	294	± 0	Very s
May 7–18 ……	231	+27	Slowish ; faint ; short.	May 30 & June 3	303	+24	Swift.
May 1…………	239	+46	Swift ; short ; faint.	May 11–18……	314	+15	V. swif
May 1–7………	254	−21	Slow ; long.	May–June ……	329	+48	V. swif
May 1–14 ……	262	+64	Rather slow.	May 29–June 4	333	+27	V. swif
May 30 ………	290	+60	Short ; slow.	May 2–6………	337	− 2½	Swift ; strea

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h m s
152	1	W	·413	8 4	15 51	14 17	8 25	−37·1 M.	23 57 32	4 38 37
153	2	Th	·416	8 5	15 51	14 45	9 18	−49·3 M.	57 41	42 33
154	3	F	·419	8 6	15 50	15 16	10 12	−61·5 M.	57 50	46 30
155	4	S	·422	8 7	15 50	15 51	11 7	−73·8 M.	58 0	50 26
156	5	**S**	·424	8 8	15 49	rises	12 4	......	58 10	54 23
157	6	M	·427	8 9	15 48	8 38	13 0	+81·7 E.	58 20	4 58 20
158	7	Tu	·430	8 10	15 47	9 36	13 56	+69·4 E.	58 31	5 2 16
159	8	W	·433	8 11	15 47	10 24	14 49	+57·2 E.	58 42	6 13
160	9	Th	·435	8 11	15 46	11 4	15 40	+45·0 E.	58 54	10 9
161	10	F	·438	8 12	15 46	11 37	16 27	+32·7 E.	59 6	14 6
162	11	S	·441	8 13	15 45	12 4	17 13	+20·5 E.	59 17	18 2
163	12	**S**	·444	8 14	15 45	12 28	17 56	+ 8·3 E.	59 29	21 59
164	13	M	·446	8 15	15 45	12 50	18 38	− 3·9 E.	59 42	25 55
165	14	Tu	·449	8 16	15 45	13 11	19 20	−16·1 E.	23 59 54	29 52
166	15	W	·452	8 16	15 44	13 32	20 3	−28·3 E.	0 0 7	33 49
167	16	Th	·455	8 16	15 44	13 54	20 46	−40·6 E.	0 20	37 45
168	17	F	·457	8 16	15 44	14 19	21 32	−52·8 E.	0 33	41 42
169	18	S	·460	8 17	15 44	14 48	22 20	−65·0 E.	0 46	45 38
170	19	**S**	·463	8 17	15 44	15 23	23 11	−77·2 E.	0 59	49 35
171	20	M	·465	8 18	15 44	sets	......	......	1 12	53 31
172	21	Tu	·468	8 18	15 45	8 6	0 4	+78·4 M.	1 25	5 57 28
173	22	W	·471	8 18	15 45	9 0	0 59	+66·1 M.	1 38	6 1 24
174	23	Th	·474	8 19	15 45	9 47	1 55	+53·9 M.	1 51	5 21
175	24	F	·476	8 19	15 45	10 27	2 51	+41·7 M.	2 4	9 18
176	25	S	·479	8 19	15 46	11 0	3 45	+29·4 M.	2 17	13 14
177	26	**S**	·482	8 18	15 46	11 29	4 39	+17·2 M.	2 30	17 11
178	27	M	·485	8 18	15 46	11 56	5 30	+ 5·0 M.	2 42	21 7
179	28	Tu	·487	8 18	15 46	12 22	6 22	− 7·2 M.	2 55	25 4
180	29	W	·490	8 18	15 47	12 48	7 13	−19·4 M.	3 7	29 0
181	30	Th	·493	8 18	15 47	13 17	8 5	−31·6 M.	0 3 19	6 32 57

	d	h	m		d	h	m
Full Moon	5	10	38	Last Quarter	13	1	35
New Moon	20	22	53	First Quarter	27	22	1

Meteor Notes.

There is so little real darkness during the nights at this season of the year that the work of observing meteors is rendered somewhat difficult. A fair number may, however, usually be seen. Fireball dates:—June 4 and 9.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
June 1–29	168	+55	Near β Urs. Maj.	June 26–July 6	294	+39	Slow.
June 2	227	+30	Near β Coronæ.	June 28	305	+ 9	Near ε Delphini.
June 3–17	249	−20	Fireballs.	June	315	+60	Swift; streaks.
June 25–30 ...	253	+47	Swift.	June	319	+32	Near ζ Cygni.
June 3–13	261	+ 5	Slowish.	June 25–30 ...	330	+77	From Cepheus.
June	282	+32	Near β Lyræ.	June 11–13......	345	± 0	Very swift.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sid Tim M No
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.	Long. of Termi-nator.		
				h m	h m	h m	h m	°	h m s	h
182	1	F	·496	8 18	15 49	13 49	8 58	−43·8 M.	0 3 31	6
183	2	S	·498	8 17	15 50	14 27	9 53	−56·0 M.	3 42	
184	3	**S**	·501	8 17	15 51	15 11	10 48	−68·3 M.	3 53	
185	4	M	·504	8 16	15 52	rises	11 44	......	4 4	
186	5	Tu	·507	8 16	15 53	8 17	12 38	+87·3 E.	4 14	
187	6	W	·509	8 15	15 54	9 1	13 30	+75·0 E.	4 25	6
188	7	Th	·512	8 15	15 55	9 37	14 19	+62·8 E.	4 34	7
189	8	F	·515	8 14	15 56	10 6	15 6	+50·6 E.	4 44	
190	9	S	·518	8 14	15 57	10 32	15 51	+38·3 E.	4 53	
191	10	**S**	·520	8 13	15 58	10 55	16 34	+26·1 E.	5 2	
192	11	M	·523	8 13	15 59	11 16	17 16	+13·9 E.	5 10	
193	12	Tu	·526	8 12	16 0	11 36	17 58	+ 1·7 E.	5 18	
194	13	W	·528	8 11	16 1	11 57	18 40	−10·5 E.	5 25	
195	14	Th	·531	8 10	16 2	12 20	19 24	−22·7 E.	5 32	
196	15	F	·534	8 9	16 3	12 47	20 11	−34·9 E.	5 39	
197	16	S	·537	8 8	16 4	13 19	21 0	−47·2 E.	5 45	
198	17	**S**	·539	8 7	16 5	13 58	21 52	−59·4 E.	5 50	
199	18	M	·542	8 6	16 6	14 45	22 47	−71·6 E.	5 56	
200	19	Tu	·545	8 5	16 7	15 42	23 44	−83·9 E.	6 0	
201	20	W	·548	8 4	16 9	sets	......	......	6 4	
202	21	Th	·550	8 3	16 10	8 25	0 41	+71·7 M.	6 7	
203	22	F	·553	8 2	16 11	9 1	1 37	+59·4 M.	6 10	7
204	23	S	·556	8 0	16 12	9 33	2 33	+47·2 M.	6 13	8
205	24	**S**	·559	7 58	16 14	10 2	3 26	+35·0 M.	6 14	
206	25	M	·561	7 56	16 15	10 28	4 19	+22·7 M.	6 15	
207	26	Tu	·564	7 54	16 17	10 53	5 11	+10·5 M.	6 16	
208	27	W	·567	7 53	16 19	11 21	6 2	− 1·7 M.	6 16	
209	28	Th	·570	7 51	16 21	11 52	6 55	−13·9 M.	6 15	
210	29	F	·572	7 50	16 23	12 28	7 48	−26·1 M.	6 14	
211	30	S	·575	7 49	16 24	13 8	8 42	−38·3 M.	6 12	
212	31	**S**	·578	7 47	16 26	13 55	9 36	−50·5 M.	0 6 9	8

	d h m		d h m
Full Moon	4 20 34	Last Quarter	12 18 57
New Moon	20 8 50	First Quarter	27 2 30

Meteor Notes.

This month is usually rich in periodical showers, though the long-contin twilight and the shortness of the nights still render observation difficult. ' *Aquarids*, R.A. 340°, Dec. −13°, max. July 28, form the chief display. F ball dates:—July 5, 12, 16, 18, 20, and 30.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Rema
	°	°			°	°	
July 27–Aug....	7	+32	Swift; streaks.	July 9–13	280	−14	Very slo
July 11–31......	11	+48	V. swift; streaks.	July 9–14	329	+36	Swift; r
July 28–Aug. 1	32	+55	*Perseids*; swift; streaks.	July–Aug.	315	+47	Swift; s
				July 25–31......	340	−13	Slow; ve
July, Aug., Sept.	48	+43	V. swift; streaks.	July–Aug.	350	+52	Very swi
July 13–17......	255	+37	Slow.	July 9–12	352	+38	Swift.
July 9–14	271	+21	Very slow.				

AUGUST 1887.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Sets.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h m s
213	1	M	·580	7 46	16 27	14 50	10 30	−62·7 M.	0 6 6	8 39 7
214	2	Tu	·583	7 44	16 28	15 50	11 22	−74·9 M.	6 2	43 3
215	3	W	·586	7 43	16 30	rises	12 12	......	5 58	47 0
216	4	Th	·589	7 42	16 32	8 8	13 0	+80·6 E.	5 53	50 56
217	5	F	·591	7 40	16 33	8 35	13 46	+68·4 E.	5 47	54 53
218	6	S	·594	7 38	16 35	8 58	14 29	+56·2 E.	5 40	8 58 49
219	7	**S**	·597	7 36	16 36	9 20	15 12	+43·9 E.	5 34	9 2 46
220	8	M	·600	7 34	16 37	9 41	15 54	+31·7 E.	5 26	6 43
221	9	Tu	·602	7 32	16 39	10 2	16 36	+19·5 E.	5 18	10 39
222	10	W	·605	7 31	16 40	10 24	17 19	+ 7·3 E.	5 10	14 36
223	11	Th	·608	7 29	16 42	10 48	18 3	− 4·9 E.	5 1	18 32
224	12	F	·611	7 27	16 44	11 17	18 50	−17·1 E.	4 51	22 29
225	13	S	·613	7 25	16 45	11 52	19 40	−29·3 E.	4 41	26 25
226	14	**S**	·616	7 23	16 46	12 34	20 33	−41·6 E.	4 30	30 22
227	15	M	·619	7 21	16 47	13 25	21 28	−53·8 E.	4 19	34 18
228	16	Tu	·622	7 19	16 49	14 26	22 25	−66·0 E.	4 7	38 25
229	17	W	·624	7 17	16 51	15 37	23 23	−78·2 E.	3 55	42 12
230	18	Th	·627	7 15	16 52	sets	......	......	3 42	46 8
231	19	F	·630	7 13	16 53	7 31	0 20	+77·4 M.	3 29	50 5
232	20	S	·633	7 11	16 55	8 1	1 16	+65·2 M.	3 15	54 1
233	21	**S**	·635	7 9	16 57	8 30	2 10	+53·0 M.	3 1	9 57 58
234	22	M	·638	7 7	16 59	8 57	3 4	+40·7 M.	2 46	10 1 54
235	23	Tu	·641	7 5	17 1	9 25	3 57	+28·5 M.	2 31	5 51
236	24	W	·643	7 3	17 2	9 55	4 51	+16·3 M.	2 16	9 47
237	25	Th	·646	7 1	17 3	10 28	5 44	+ 4·1 M.	2 0	13 44
238	26	F	·649	6 59	17 5	11 7	6 38	− 8·1 M.	1 43	17 41
239	27	S	·652	6 57	17 7	11 53	7 32	−20·3 M.	1 26	21 37
240	28	**S**	·654	6 55	17 8	12 45	8 25	−32·5 M.	1 9	25 34
241	29	M	·657	6 53	17 10	13 43	9 18	−44·7 M.	0 51	29 30
242	30	Tu	·660	6 51	17 12	14 45	10 8	−57·0 M.	0 33	33 27
243	31	W	·663	6 49	17 14	15 50	10 56	−69·2 M.	0 0 15	10 37 23

	d h m		d h m
Full Moon	3 8 40	Last Quarter	11 11 37
New Moon	18 17 39	First Quarter	25 8 21

Meteor Notes.

August is usually the richest month in the year for meteoric displays, the *Perseids*, on Aug. 10, being the principal shower. Meteors from neighbouring radiants are usually observed from Aug. 6 to Aug. 12. Fireball dates:—Aug. 4, 10, 16, and 25.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
Aug.–Sept.	6	+11	Swift.	Aug. 6–12	96	+71	Slow.
August	25	+42	Swift; streaks.	Aug. 21–25	291	+60	Slow; trained; brilliant.
Aug., Sept., Oct.	30	+36	N. of β Trianguli. [streaks.	August	291	+70	Swift; short.
Aug. 1–19	44	+56	*Perseids*; swift	July 27–Aug. 17	292	+52	Rather slow.
Aug. 8–11	44	+25	Swift; streaks; long.	Aug.–Sept. ...	334	+50	Swift.
Aug. 3–23	61	+49	*V. swift; streaks.*	July–August–Sept. 8	335	+28	Swift.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Si Ti M N
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h
244	1	Th	·665	6 46	17 15	6 38	11 42	......	23 59 56	10
245	2	F	·668	6 44	17 16	7 3	12 26	+86·5 E.	59 37	
246	3	S	·671	6 42	17 18	7 25	13 9	+74·3 E.	59 18	
247	4	**S**	·674	6 40	17 20	7 46	13 51	+62·0 E.	58 58	
248	5	M	·676	6 37	17 21	8 6	14 33	+49·8 E.	58 39	10
249	6	Tu	·679	6 35	17 23	8 28	15 15	+37·6 E.	58 19	11
250	7	W	·682	6 32	17 25	8 51	15 58	+25·4 E.	57 58	
251	8	Th	·685	6 29	17 26	9 17	16 44	+13·2 E.	57 38	
252	9	F	·687	6 27	17 27	9 48	17 31	+ 1·0 E.	57 17	
253	10	S	·690	6 25	17 29	10 26	18 22	−11·2 E.	56 57	
254	11	**S**	·693	6 22	17 31	11 12	19 14	−23·4 E.	56 36	
255	12	M	·695	6 20	17 32	12 7	20 9	−35·6 E.	56 15	
256	13	Tu	·698	6 18	17 33	13 12	21 5	−47·8 E.	55 54	
257	14	W	·701	6 16	17 35	14 25	22 2	−60·0 E.	55 33	
258	15	Th	·704	6 14	17 36	15 44	22 59	−72·2 E.	55 12	
259	16	F	·706	6 12	17 38	17 7	23 55	−84·4 E.	54 51	
260	17	S	·709	6 10	17 40	sets	......	......	54 30	
261	18	**S**	·712	6 7	17 42	6 55	0 50	+71·2 M.	54 9	
262	19	M	·715	6 5	17 43	7 24	1 45	+59·0 M.	53 48	
263	20	Tu	·717	6 2	17 45	7 54	2 41	+46·8 M.	53 27	11
264	21	W	·720	6 0	17 46	8 27	3 36	+34·6 M.	53 6	12
265	22	Th	·723	5 58	17 48	9 5	4 32	+22·4 M.	52 45	
266	23	F	·726	5 56	17 49	9 49	5 27	+10·2 M.	52 24	
267	24	S	·728	5 54	17 51	10 40	6 22	− 2·0 M.	52 3	
268	25	**S**	·731	5 52	17 53	11 37	7 14	−14·2 M.	51 43	
269	26	M	·734	5 50	17 55	12 38	8 5	−26·4 M.	51 22	
270	27	Tu	·737	5 47	17 56	13 42	8 54	−38·6 M.	51 2	
271	28	W	·739	5 45	17 58	14 46	9 40	−50·8 M.	50 42	
272	29	Th	·742	5 43	17 59	15 50	10 24	−63·0 M.	50 22	
273	30	F	·745	5 41	18 1	16 54	11 7	−75·2 M.	23 50 2	12

	d	h	m		d	h	m
Full Moon	1	23	13	Last Quarter	10	3	3
New Moon	17	2	0	First Quarter	23	17	4

Meteor Notes.

Except for fireballs, which may be looked for on September 1, 9, 15, 16, 24, the month is not a particularly important one for meteors. Sept. 10 is principal date.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Rema
	°	°			°	°	
Aug., Sept., Oct.	31	+18	S. of α Arietis.	Sept.–Oct.	105	+51	Very swi
Sept. 1–23	62	+37	Swift; streaks.	Aug.–Sept.	282	+42	Swift; l long.
Sept. 4–22	73	+14	Swift; streaks.				
Sept. 21, Oct. 2.	74	+41	Swift; streaks.	Sept.–Oct.	292	+70	Rather s
Sept.–Nov.	78	+57	Swift.	Sept. 1	306	+54	Swift; b
Sept. 15–19 ...	88	+18	V.swift; streaks.	Aug.–Sept.	346	± 0	Slow; br
Sept. 14–26 ...	98	+43	V.swift; streaks.	Sept. 1–15	354	+38	Very swi

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h m s
274	1	S	·747	5 40	18 3	5 51	11 49	……	23 49 43	12 39 36
275	2	**S**	·750	5 38	18 5	6 11	12 31	+80·5 E.	49 24	43 33
276	3	M	·753	5 35	18 7	6 33	13 13	+68·3 E.	49 5	47 30
277	4	Tu	·756	5 32	18 9	6 55	13 56	+56·1 E.	48 47	51 26
278	5	W	·758	5 30	18 10	7 20	14 41	+43·9 E.	48 28	55 23
279	6	Th	·761	5 27	18 12	7 49	15 27	+31·7 E.	48 11	12 59 19
280	7	F	·764	5 25	18 14	8 24	16 16	+19·5 E.	47 53	13 3 16
281	8	S	·767	5 22	18 16	9 5	17 6	+ 7·3 E.	47 36	7 12
282	9	**S**	·769	5 20	18 17	9 55	17 59	− 4·9 E.	47 20	11 9
283	10	M	·772	5 18	18 19	10 54	18 53	−17·1 E.	47 4	15 5
284	11	Tu	·775	5 15	18 20	12 2	19 47	−29·3 E.	46 49	19 2
285	12	W	·778	5 13	18 22	13 16	20 42	−41·5 E.	46 34	22 59
286	13	Th	·780	5 11	18 24	14 35	21 37	−53·7 E.	46 19	26 55
287	14	F	·783	5 8	18 25	15 57	22 32	−65·8 E.	46 5	30 52
288	15	S	·786	5 6	18 27	17 21	23 28	−78·0 E.	45 52	34 48
289	16	**S**	·789	5 4	18 28	sets	……	……	45 39	38 45
290	17	M	·791	5 2	18 30	5 49	0 24	+77·6 M.	45 27	42 41
291	18	Tu	·794	5 0	18 31	6 21	1 21	+65·5 M.	45 15	46 38
292	19	W	·797	4 58	18 32	6 58	2 18	+53·3 M.	45 4	50 34
293	20	Th	·800	4 56	18 34	7 41	3 16	+41·1 M.	44 54	54 31
294	21	F	·802	4 54	18 36	8 30	4 13	+29·0 M.	44 44	13 58 27
295	22	S	·805	4 52	18 38	9 26	5 8	+16·8 M.	44 35	14 2 24
296	23	**S**	·808	4 50	18 40	10 27	6 1	+ 4·6 M.	44 26	6 21
297	24	M	·810	4 47	18 42	11 31	6 51	− 7·6 M.	44 18	10 17
298	25	Tu	·813	4 45	18 44	12 36	7 38	−19·8 M.	44 11	14 14
299	26	W	·816	4 43	18 46	13 41	8 23	−31·9 M.	44 5	18 10
300	27	Th	·819	4 41	18 48	14 46	9 6	−44·1 M.	43 59	22 7
301	28	F	·821	4 39	18 50	15 50	9 48	−56·3 M.	43 54	26 3
302	29	S	·824	4 37	18 51	16 54	10 30	−68·5 M.	43 50	30 0
303	30	**S**	·827	4 36	18 53	17 57	11 12	−80·7 M.	43 46	33 56
304	31	M	·830	4 34	18 55	19 1	11 54	……	23 43 43	14 37 53

	d h m		d h m		d h m
Full Moon	1 15 47	**Last Quarter**	9 16 57	**Full Moon**	31 9 31
New Moon	16 10 35	**First Quarter**	23 5 46		

Meteor Notes.

The chief shower of October is the *Orionids*, R.A. 90°, Dec. +15°; but there are a large number of active radiants visible during the month, the principal displays taking place on Oct. 1 and Oct. 16–23. Fireball dates:—Oct. 10, 14, 18, 24, and 29.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
t. 7–20 ……	31	+ 9	Slow; trained.	Oct.–Nov. ……	105	+12	Swift; streaks.
t. 6–16 ……	42	+55	Slow.	Sept. 25–Oct. 28	108	+24	Swift; streaks.
t. 8 and 15…	46	+26	Swift.	Oct. 2–19 ……	133	+79	Swift; streaks.
pt., Oct., Nov.	78	+32	Swift.	Oct.–Nov. ……	133	+21	Very swift.
t. 17–21 ……	90	+15	Swift; streaks.	Oct. 2…………	225	+52	Slow; brilliant.
t. 6–12 ……	103	+33	Swift; streaks.	Oct. 2–20 ……	310	+77	Slow; faint.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h m s
305	1	Tu	·832	4 32	18 57	5 23	12 39	+75·0 E.	23 43 42	14 41 50
306	2	W	·835	4 31	18 59	5 51	13 5	+62·9 E.	43 40	45 46
307	3	Th	·838	4 29	19 0	6 24	14 13	+50·7 E.	43 40	49 43
308	4	F	·841	4 27	19 2	7 3	15 3	+38·5 E.	43 41	53 39
309	5	S	·843	4 25	19 4	7 49	15 54	+26·3 E.	43 42	14 57 36
310	6	**S**	·846	4 24	19 5	8 44	16 47	+14·1 E.	43 44	15 1 32
311	7	M	·849	4 23	19 7	9 47	17 40	+ 1·9 E.	43 47	5 29
312	8	Tu	·852	4 22	19 9	10 57	18 33	−10·3 E.	43 51	9 25
313	9	W	·854	4 20	19 10	12 12	19 25	−22·4 E.	43 56	13 22
314	10	Th	·857	4 19	19 12	13 30	20 18	−34·6 E.	44 2	17 19
315	11	F	·860	4 17	19 14	14 50	21 11	−46·8 E.	44 8	21 15
316	12	S	·862	4 16	19 16	16 12	22 6	−59·0 E.	44 15	25 12
317	13	**S**	·865	4 14	19 18	17 36	23 1	−71·1 E.	44 24	29 8
318	14	M	·868	4 12	19 19	sets	23 59	……	44 33	33 5
319	15	Tu	·871	4 11	19 21	4 48	……	+84·6 M.	44 43	37 1
320	16	W	·873	4 10	19 23	5 28	0 58	+72·4 M.	44 53	40 58
321	17	Th	·876	4 9	19 25	6 16	1 57	+60·3 M.	45 5	44 54
322	18	F	·879	4 8	19 27	7 11	2 55	+48·1 M.	45 17	48 51
323	19	S	·882	4 7	19 28	8 12	3 51	+35·9 M.	45 31	52 48
324	20	**S**	·884	4 6	19 30	9 17	4 44	+23·8 M.	45 45	15 56 44
325	21	M	·887	4 4	19 31	10 24	5 33	+11·6 M.	46 0	16 0 41
326	22	Tu	·890	4 3	19 33	11 30	6 20	− 0·6 M.	46 15	4 37
327	23	W	·893	4 2	19 34	12 35	7 4	−12·7 M.	46 32	8 34
328	24	Th	·895	4 0	19 36	13 39	7 46	−24·9 M.	46 49	12 30
329	25	F	·898	3 59	19 37	14 42	8 28	−37·0 M.	47 7	16 27
330	26	S	·901	3 58	19 39	15 46	9 9	−49·2 M.	47 25	20 23
331	27	**S**	·904	3 57	19 40	16 50	9 52	−61·3 M.	47 45	24 20
332	28	M	·906	3 56	19 42	17 55	10 36	−73·5 M.	48 5	28 17
333	29	Tu	·909	3 55	19 44	19 0	11 21	−85·7 M.	48 26	32 13
334	30	W	·912	3 54	19 45	20 3	12 9	……	23 48 47	16 36 10

	d h m		d h m
Last Quarter	8 5 2	New Moon	14 20 8
First Quarter	21 22 43	Full Moon	30 3 20

Meteor Notes.

The two most interesting November showers are the *Leonids*, R.A. 149°, Dec. +22°, max. Nov. 14, and the *Andromedes*, R.A. 24°, Dec. +44°, max. Nov. 27; but no great display of either is expected this year. Other well-marked showers are the *Taurids*, R.A. 60°, Dec. +20°, and *Leo Minorids*, R.A. 155°, Dec. +40°. Fireball dates:—Nov. 1, 5, 14, 20, and 29.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
Nov. 24–30 …	24	+44	V. slow; trained.	Oct., Nov., Dec.	142	+27	Very swift.
Oct. 30–Nov. 1	43	+22	Slow; brilliant.	Oct., Nov., Dec.	143	+49	Very swift.
Oct. 25–Nov. 28	60	+20	Rather slow; bright.	Nov. 11–15……	149	+22	Swift; streaks.
				Nov. 13–28……	155	+40	Swift; streaks.
Nov. 27–30……	60	+49	Very swift.	Nov. 14–17……	166	+31	Swift; streaks.
November 9 …	102	+73	Very swift.	Nov. 30–Dec. 4	194	+43	V. swift; streak
Nov. 13–16……	125	+41	Swift; streaks.	Nov. 1–6 ……	348	+52	Rather slow.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h m s
335	1	Th	·915	3 53	19 47	5 1	12 59	+69·9 E.	23 49 9	16 40 6
336	2	F	·917	3 52	19 48	5 45	13 51	+57·8 E.	49 32	44 3
337	3	S	·920	3 52	19 49	6 38	14 44	+45·6 E.	49 56	47 59
338	4	**S**	·923	3 51	19 51	7 39	15 37	+33·5 E.	50 20	51 56
339	5	M	·925	3 51	19 52	8 46	16 29	+21·3 E.	50 44	55 52
340	6	Tu	·928	3 51	19 53	9 58	17 21	+ 9·2 E.	51 9	16 59 49
341	7	W	·931	3 50	19 54	11 14	18 12	− 3·0 E.	51 35	17 3 46
342	8	Th	·934	3 50	19 56	12 31	19 3	−15·2 E.	52 1	7 42
343	9	F	·936	3 50	19 57	13 49	19 55	−27·3 E.	52 28	11 39
344	10	S	·939	3 49	19 58	15 9	20 48	−39·5 E.	52 55	15 35
345	11	**S**	·942	3 49	19 59	16 31	21 42	−51·6 E.	53 23	19 32
346	12	M	·945	3 49	20 0	17 52	22 39	−63·8 E.	53 51	23 28
347	13	Tu	·947	3 49	20 1	19 9	23 38	−76·0 E.	54 19	27 25
348	14	W	·950	3 49	20 2	sets	……	……	54 48	31 21
349	15	Th	·953	3 49	20 3	4 53	0 37	+79·7 M.	55 17	35 18
350	16	F	·956	3 49	20 4	5 52	1 35	+67·6 M.	55 46	39 15
351	17	S	·958	3 49	20 5	6 57	2 31	+55·4 M.	56 16	43 11
352	18	**S**	·961	3 50	20 5	8 5	3 23	+43·3 M.	56 45	47 8
353	19	M	·964	3 50	20 6	9 13	4 12	+31·1 M.	57 15	51 4
354	20	Tu	·967	3 50	20 6	10 20	4 58	+19·0 M.	57 45	55 1
355	21	W	·969	3 51	20 6	11 25	5 42	+ 6·8 M.	58 15	17 58 57
356	22	Th	·972	3 51	20 7	12 30	6 24	− 5·4 M.	58 45	18 2 54
357	23	F	·975	3 51	20 7	13 34	7 6	−17·6 M.	59 15	6 50
358	24	S	·977	3 52	20 7	14 37	7 48	−29·7 M.	23 59 45	10 47
359	25	**S**	·980	3 53	20 8	15 42	8 31	−41·9 M.	0 0 15	14 44
360	26	M	·983	3 53	20 8	16 46	9 15	−54·1 M.	0 45	18 40
361	27	Tu	·986	3 54	20 8	17 50	10 2	−66·2 M.	1 14	22 37
362	28	W	·988	3 55	20 9	18 53	10 52	−78·4 M.	1 44	26 33
363	29	Th	·991	3 56	20 9	rises	11 44	……	2 13	30 30
364	30	F	·994	3 57	20 8	4 30	12 37	+77·3 E.	2 42	34 26
365	31	S	·997	3 58	20 8	5 29	13 31	+65·2 E.	0 3 11	18 38 23

	d	h	m		d	h	m
Last Quarter	7	15	11	New Moon	14	7	22
First Quarter	21	19	1	Full Moon	29	20	14

Meteor Notes.

The principal December shower is that of the *Geminids*, R.A. 107°, Dec. +33°, max. Dec. 10–11. The *Taurids* II., R.A. 80°, Dec. +23°, max. Dec. 6, also yield a well-marked shower. Fireball dates:—Dec. 2, 8, 11, 14, 19, 21, and 27.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
Dec. 1–10 ……	44	+56	V. slow; faint	Dec. 23–27.. …	130	+49	Near λ Ursæ Maj.
Dec. 1–12 ……	80	+23	Slow; bright.	Dec. 10–11……	143	+39	Swift; streaks.
Dec. 30–31……	92	+57	Slow; brilliant.	Dec. 7–10 ……	145	+ 7	Swift; streaks.
Dec. 4–12 ……	107	+33	Swift; short.	Dec. 1–16 ……	158	+72	Near λ Draconis.
Dec. 1–12 ……	110	+24	Rather swift.	Dec. 4–9………	161	+58	V. swift; streaks.
December ……	117	+32	Rather swift.	Dec.–Jan. ……	201	+57	Slow.

Day.			Fraction of year.	Sun.		Moon.			Mean Time at Apparent Noon.	Sidereal Time at Mean Noon.
Year.	Month.	Week.		Sets.	Rises.	Rises.	Souths.	Long. of Terminator.		
				h m	h m	h m	h m	°	h m s	h m s
305	1	Tu	·832	4 32	18 57	5 23	12 39	+75·0 E.	23 43 42	14 41 50
306	2	W	·835	4 31	18 59	5 51	13 5	+62·9 E.	43 40	45 46
307	3	Th	·838	4 29	19 0	6 24	14 13	+50·7 E.	43 40	49 43
308	4	F	·841	4 27	19 2	7 3	15 3	+38·5 E.	43 41	53 39
309	5	S	·843	4 25	19 4	7 49	15 54	+26·3 E.	43 42	14 57 36
310	6	**S**	·846	4 24	19 5	8 44	16 47	+14·1 E.	43 44	15 1 32
311	7	M	·849	4 23	19 7	9 47	17 40	+ 1·9 E.	43 47	5 29
312	8	Tu	·852	4 22	19 9	10 57	18 33	−10·3 E.	43 51	9 25
313	9	W	·854	4 20	19 10	12 12	19 25	−22·4 E.	43 56	13 22
314	10	Th	·857	4 19	19 12	13 30	20 18	−34·6 E.	44 2	17 19
315	11	F	·860	4 17	19 14	14 50	21 11	−46·8 E.	44 8	21 15
316	12	S	·862	4 16	19 16	16 12	22 6	−59·0 E.	44 15	25 12
317	13	**S**	·865	4 14	19 18	17 36	23 1	−71·1 E.	44 24	29 8
318	14	M	·868	4 12	19 19	sets	23 59	……	44 33	33 5
319	15	Tu	·871	4 11	19 21	4 48	……	+84·6 M.	44 43	37 1
320	16	W	·873	4 10	19 23	5 28	0 58	+72·4 M.	44 53	40 58
321	17	Th	·876	4 9	19 25	6 16	1 57	+60·3 M.	45 5	44 54
322	18	F	·879	4 8	19 27	7 11	2 55	+48·1 M.	45 17	48 51
323	19	S	·882	4 7	19 28	8 12	3 51	+35·9 M.	45 31	52 48
324	20	**S**	·884	4 6	19 30	9 17	4 44	+23·8 M.	45 45	15 56 44
325	21	M	·887	4 4	19 31	10 24	5 33	+11·6 M.	46 0	16 0 41
326	22	Tu	·890	4 3	19 33	11 30	6 20	− 0·6 M.	46 15	4 37
327	23	W	·893	4 2	19 34	12 35	7 4	−12·7 M.	46 32	8 34
328	24	Th	·895	4 0	19 36	13 39	7 46	−24·9 M.	46 49	12 30
329	25	F	·898	3 59	19 37	14 42	8 28	−37·0 M.	47 7	16 27
330	26	S	·901	3 58	19 39	15 46	9 9	−49·2 M.	47 25	20 23
331	27	**S**	·904	3 57	19 40	16 50	9 52	−61·3 M.	47 45	24 20
332	28	M	·906	3 56	19 42	17 55	10 36	−73·5 M.	48 5	28 17
333	29	Tu	·909	3 55	19 44	19 0	11 21	−85·7 M.	48 26	32 13
334	30	W	·912	3 54	19 45	20 3	12 9	……	23 48 47	16 36 10

	d	h	m		d	h	m
Last Quarter	8	5	2	New Moon	14	20	8
First Quarter	21	22	43	Full Moon	30	3	20

Meteor Notes.

The two most interesting November showers are the *Leonids*, R.A. 149°, Dec. +22°, max. Nov. 14, and the *Andromedes*, R.A. 24°, Dec. +44°, max. Nov. 27; but no great display of either is expected this year. Other well-marked showers are the *Taurids*, R.A. 60°, Dec. +20°, and *Leo Minorids*, R.A. 155°, Dec. +40°. Fireball dates:—Nov. 1, 5, 14, 20, and 29.

Duration.	R.A.	Dec.	Remarks.	Duration.	R.A.	Dec.	Remarks.
	°	°			°	°	
Nov. 24–30 …	24	+44	V. slow; trained.	Oct., Nov., Dec.	142	+27	Very swift.
Oct. 30–Nov. 1	43	+22	Slow; brilliant.	Oct., Nov., Dec.	143	+49	Very swift.
Oct. 25–Nov. 28	60	+20	Rather slow; bright.	Nov. 11–15……	149	+22	Swift; streaks.
				Nov. 13–28……	155	+40	Swift; streaks.
Nov. 27–30……	60	+49	Very swift.	Nov. 14–17……	166	+31	Swift; streaks.
November 9 …	102	+73	Very swift.	Nov. 30–Dec. 4	194	+43	V. swift; streaks.
Nov. 13–16……	125	+41	Swift; streaks.	Nov. 1–6 ……	348	+52	Rather slow.

URANUS (♅).

.	R.A.	Dec.	Diam.	Rises.	Transits.	Sets.
	h m s	° ′	″	h m	h m	h m
1	12 46 38	4 15 S.	3·8	12 18	18 0	23 42
31	12 46 42	4 14	3·8	10 20	16 2	21 44
2	12 43 55	3 56	4·0	8 19	14 2	19 45
1	12 39 26	3 27	4·0	6 13	11 59	17 45
1	12 34 59	2 59	3·9	4 8	9 57	15 46
31	12 32 13	2 43	3·8	2 6	7 56	13 46
30	12 32 7	2 44 S.	3·8	0 8	5 58	11 48

NEPTUNE (♆).

1	3 33 45	17 24 N.	1.3	1 13	8 49	16 25
31	3 32 27	17 22	1·3	23 10	6 50	14 26
2	3 33 12	17 26	1·3	21 12	4 53	12 30
1	3 35 52	17 37	1·3	19 16	2 58	10 36
30	3 51 47	18 28	1·3	11 35	19 18	3 5
29	3 53 8	18 31	1·3	9 37	17 21	1 9
er 28	3 52 26	18 27	1·3	7 39	15 22	23 5
28	3 50 0	18 19	1·3	5 40	13 22	21 4
er 27	3 46 37	18 8	1·3	3 39	11 20	19 1
er 27	3 43 29	17 58 N.	1·3	1 39	9 19	16 59

s.—In quadrature, January 2^d 14^h; June 30^d 2^h. Stationary, January June 15^d 23^h. In opposition, March 31^d 0^h. In conjunction, October

ne.—Stationary, February 4^d 7^h; September 2^d 21^h. In quadrature, r 13^d 13^h; August 23^d 1^h. In conjunction, May 18^d 8^h. In oppo- ovember 20^d 18^h.

ECLIPSES IN 1887.

year 1887 there will be two eclipses of the Sun and two of

I. *A Partial Eclipse of the Moon, February 7–8.*

(Invisible at Greenwich.)

		d	h	m
First contact with Penumbra..................	Feb.	7	20	2·5
,, ,, ,, Shadow.....................			21	14·2
Middle of Eclipse			22	22·1
Last contact with Shadow			23	30·0
,, ,, ,, Penumbra		8	0	41·7

Magnitude of Eclipse (Moon's diameter = 1) 0·432

st contact with the Shadow takes place at 52° towards the E. of the ; the last contact at 27° towards the W. (for *Direct* image).

MERCURY (☿).

1887.		R.A.			Dec.		Diam.	Rises.		Transits.	
		h	m	s	°	′	″	h	m	h	m
January	1	17	20	49	22	25 S.	5·4	18	37	22	39
	11	18	22	56	23	54	5·0	19	14	23	3
	21	19	30	0	23	23	4·8	19	37	23	31
	31	20	39	22	20	32	4·8	19	49	0	0
February	10	21	49	27	15	13	4·8	19	43	0	28
	20	22	58	2	7	36 S.	5·4	19	34	0	58
March	2	23	55	37	0	43 N.	6·6	19	7	1	16
	12	0	18	21	5	27	9·0	18	23	0	59
	22	23	57	56	3	15 N.	11·0	17	32	23	52
April	1	23	36	37	1	35 S.	10·6	16	58	22	54
	11	23	45	31	3	6	9·0	16	37	22	26
	21	0	18	24	0	52 S.	7·6	16	21	22	22
May	1	1	6	13	4	1 N.	6·4	16	7	22	31
	11	2	6	34	10	39	5·6	15	53	22	53
	21	3	21	57	17	57	5·2	15	50	23	31
	31	4	52	11	23	41	5·2	16	3	0	18
June	10	6	22	2	25	22	5·6	16	40	1	8
	20	7	35	4	23	21	6·6	17	30	1	42
	30	8	26	12	19	29	8·0	18	4	1	53
July	10	8	52	42	15	34	9·6	18	12	1	40
	20	8	49	55	13	24	11·0	17	38	0	58
	30	8	23	43	14	21	11·2	16	26	23	46
August	9	8	10	20	17	2	9·2	15	23	22	57
	19	8	41	3	18	4	6·8	15	12	22	52
	29	9	47	45	14	54	5·4	16	2	23	22
September	8	11	1	29	8	8	5·0	17	13	23	56
	18	12	7	52	0	16 N.	4·8	18	18	0	20
	28	13	7	32	7	16 S.	5·0	19	18	0	40
October	8	14	3	20	13	53	5·2	20	7	0	56
	18	14	56	13	19	12	5·8	20	52	1	10
	28	15	42	22	22	40	6·8	21	19	1	16
November	7	16	4	51	23	13	8·4	21	0	0	59
	17	15	33	11	18	48	9·8	19	14	23	39
	27	15	3	26	14	39	8·2	17	49	22	36
December	7	15	31	39	16	54	6·4	17	55	22	29
	17	16	25	26	20	44	5·4	18	34	22	44
	27	17	28	26	23	34 S.	5·0	19	15	23	8

At greatest elongation :—18° 9′ E., March 4^d 23^h ; 27° 20′ W., 18^d 9^h; 25° 51′ E., June 30^d 22^h; 18° 36′ W., August 16^d 8^h; 23° 48′ E., O 26^d 15^h; 20° 32′ W., December 4^d 20^h.

In superior conjunction :—February 6^d 6^h; May 27^d 2^h; September 10

In inferior conjunction :—March 21^d 15^h; July 28^d 17^h; November 17

Stationary :—March 11^d 15^h; April 3^d 1^h; July 14^d 2^h; August 7^d November 6^d 20^h; November 26^d 11^h.

VENUS (♀).

1887.		R.A.	Dec.	Diam.	Rises.	Transits.	Sets.
		h m s	° ′	″	h m	h m	h m
January	1	19 17 55	23 13 S.	9·8	20 42	0 35	4 29
	11	20 11 35	21 17	10·0	20 43	0 49	4 56
	21	21 3 25	18 18	10·0	20 36	1 1	5 27
	31	21 53 8	14 27	10·2	20 24	1 12	6 0
February	10	22 40 51	9 57	10·4	20 8	1 20	6 33
	20	23 27 1	5 0 S.	10·6	19 49	1 27	7 5
March	2	0 12 14	0 9 N.	10·8	19 28	1 32	7 37
	12	0 57 12	5 19	11·0	19 7	1 38	8 9
	22	1 42 36	10 18	11·2	18 50	1 44	8 39
April	1	2 29 3	14 53	11·6	18 29	1 51	9 14
	11	3 16 58	18 52	12·2	18 13	2 0	9 47
	21	4 6 31	22 3	12·6	18 4	2 10	10 17
May	1	4 57 29	24 15	13·4	17 59	2 21	10 44
	11	5 49 9	25 22	14·0	18 4	2 33	11 3
	21	6 40 35	25 19	14·8	18 16	2 45	11 15
	31	7 30 40	24 8	16·0	18 36	2 56	11 17
June	10	8 18 25	21 56	17·0	19 0	3 4	11 10
	20	9 3 9	18 53	18·8	19 25	3 10	10 55
	30	9 44 32	15 10	20·6	19 49	3 12	10 35
July	10	10 22 17	11 0	23·0	20 10	3 10	10 10
	20	10 56 10	6 37	25·8	20 27	3 4	9 40
	30	11 25 42	2 12 N.	29·4	20 39	2 54	9 8
August	9	11 49 42	2 0 S.	34·0	20 43	2 39	8 33
	19	12 6 15	5 38	40·0	20 39	2 16	7 50
	29	12 12 29	8 17	46·6	20 18	1 43	7 4
September	8	12 5 33	9 17	54·0	19 34	0 56	6 12
	18	11 47 3	8 2	58·4	18 30	23 53	5 22
	28	11 26 32	5 0	58·0	17 15	22 53	4 38
October	8	11 16 3	1 49 S.	52·5	16 10	22 5	4 3
	18	11 20 20	0 8 N.	45·3	15 26	21 31	3 38
	28	11 37 10	0 29 N.	38·8	15 4	21 10	3 17
November	7	12 2 53	0 32 S.	33·5	14 55	20 56	2 58
	17	12 34 34	2 37	29·2	14 58	20 49	2 40
	27	13 10 19	5 25	25·9	15 10	20 46	2 22
December	7	13 49 10	8 38	23·0	15 25	20 45	2 5
	17	14 30 44	11 59	20·8	15 46	20 48	1 50
	27	15 14 47	15 12 S.	19·2	16 8	20 53	1 38

At greatest elongation:—45° 32′ E., July 13^{d} 8^{h}; 46° 47′ W., December 1^{d} 21^{h}.
In inferior conjunction:—September 21^{d} 4^{h}.
At greatest brilliancy:—August 16; October 28.
Stationary:—August 28^{d} 23^{h}; October 10^{d} 1^{h}.

II. *An Annular Eclipse of the Sun*, 1887, *February* 22.

(Invisible at Greenwich.)

Elements.

Greenwich M.T. of ☌ in R.A., February 22, $9^h\ 13^m\ 5^s{\cdot}5$.
☉'s and ☾'s R.A. $22^h\ 23^m\ 28^s{\cdot}25$. Hourly motions $9^s{\cdot}52$ and $116^s{\cdot}44$.

	°	′	″		′	″
☉'s Declination	10	3	27·3 S.	Hourly motion	0	54·8 N.
☾'s Declination	10	37	18·3 S.	Hourly motion	8	13·1 N.
☉'s Equat. Hor. Parallax			8·9	☉'s true Semidiameter .	16	11·7
☾'s Equat. Hor. Parallax		54	6·1	☾'s true Semidiameter .	14	46·0

		h	m		°	′		°	′	
Eclipse begins	Feb. 22	6	40·8	in Long.	165	25	E., and in Lat.	37	39	S.
Central eclipse begins		7	58·7		140	47	E.,	51	50	
Central eclipse at nobn		9	13·1		134	52	W.,	49	10	
Central eclipse ends ...		11	7·4		69	27	W.,	21	31	
Eclipse ends		12	25·4		91	41	W.,	7	1	S.

The path of the central shadow lies almost entirely over the South Pacific Ocean, the only points of land from which the annular phase could possibly be seen being the Macquarie Islands, about 750 miles to the south of New Zealand, and Iquique and Cobija on the coast of South America, the central line passing over the mouth of the river Loa.

III. *A Partial Eclipse of the Moon*, *August* 3.

(Visible at Greenwich.)

	d	h	m
First contact with Penumbra..................	Aug. 3	6	11·9
" " " Shadow.....................		7	35·7
Middle of Eclipse		8	48·9
Last contact with Shadow		10	2·1
" " " Penumbra....................		11	25·9

Magnitude of Eclipse (Moon's diameter = 1) 0·419

The first contact with the Shadow takes place at 130° towards the E. of the N. point; the last contact at 151° towards the W. (for *Direct* image).

IV. *A Total Eclipse of the Sun*, 1887, *August* 18.

(Partly visible as a partial eclipse at Greenwich.)

Elements.

Greenwich M.T. of ☌ in R.A., Aug. 18, $17^h\ 15^m\ 30^s{\cdot}6$.
☉'s and ☾'s R.A. $9^h\ 52^m\ 31^s{\cdot}09$. Hourly motions $9^s{\cdot}30$ and $146^s{\cdot}54$.

	°	′	″		′	″
☉'s Declination	12	54	5·2 N.	Hourly motion	0	48·8
☾'s Declination	13	33	11·7 N.	Hourly motion	9	12·9
☉'s Equat. Hor. Parallax...			8·7	☉'s true Semidiameter .	15	50·6
☾'s Equat. Hor. Parallax...		60	13·5	☾'s true Semidiameter .	16	26·3

		h	m		°	′		°	′	
Eclipse begins	Aug. 18	15	5·5	in Long.	34	30	E., and in Lat.	37	27	N.
Central eclipse begins		16	11·1		11	25	E.,	51	38	
Central eclipse at noon		17	15·5		102	0	E.,	53	47	
Central eclipse ends...		18	53·2		173	32	E.,	24	34	
Eclipse ends		19	58·9		153	26	E.,	9	57	N.

The path of totality commences a little to the west of Berlin, which lies almost on the central line, passes onward into Russia, the total phase being visible from Konigsberg and Wilna, and at places a little to the north of Moscow, thence into Siberia and across Manchouria and the Sea of Japan into Japan, where the central line lies some 70 miles to the north of Tokio. The last available station is the island of Rico de Oro in the North Pacific Ocean. The duration of totality on the central line near Moscow is about 147 seconds, near Tokio about 190 seconds.

Uranus (♅).

1887.		R.A.	Dec.	Diam.	Rises.	Transits.	Sets.
		h m s	° '	"	h m	h m	h m
January	1	12 46 38	4 15 S.	3·8	12 18	18 0	23 42
	31	12 46 42	4 14	3·8	10 20	16 2	21 44
March	2	12 43 55	3 56	4·0	8 19	14 2	19 45
April	1	12 39 26	3 27	4·0	6 13	11 59	17 45
May	1	12 34 59	2 59	3·9	4 8	9 57	15 46
	31	12 32 13	2 43	3·8	2 6	7 56	13 46
June	30	12 32 7	2 44 S.	3·8	0 8	5 58	11 48

Neptune (♆).

January	1	3 33 45	17 24 N.	1.3	1 13	8 49	16 25
	31	3 32 27	17 22	1·3	23 10	6 50	14 26
March	2	3 33 12	17 26	1·3	21 12	4 53	12 30
April	1	3 35 52	17 37	1·3	19 16	2 58	10 36
July	30	3 51 47	18 28	1·3	11 35	19 18	3 5
August	29	3 53 8	18 31	1·3	9 37	17 21	1 9
September	28	3 52 26	18 27	1·3	7 39	15 22	23 5
October	28	3 50 0	18 19	1·3	5 40	13 22	21 4
November	27	3 46 37	18 8	1·3	3 39	11 20	19 1
December	27	3 43 29	17 58 N.	1·3	1 39	9 19	16 59

Uranus.—In quadrature, January $2^{d}\ 14^{h}$; June $30^{d}\ 2^{h}$. Stationary, January $16^{d}\ 15^{h}$; June $15^{d}\ 23^{h}$. In opposition, March $31^{d}\ 0^{h}$. In conjunction, October $5^{d}\ 23^{h}$.

Neptune.—Stationary, February $4^{d}\ 7^{h}$; September $2^{d}\ 21^{h}$. In quadrature, February $13^{d}\ 13^{h}$; August $23^{d}\ 1^{h}$. In conjunction, May $18^{d}\ 8^{h}$. In opposition, November $20^{d}\ 18^{h}$.

ECLIPSES IN 1887.

In the year 1887 there will be two eclipses of the Sun and two of Moon.

I. *A Partial Eclipse of the Moon, February* 7–8.
(Invisible at Greenwich.)

		d	h	m
First contact with Penumbra..................	Feb.	7	20	2·5
" " " Shadow......................			21	14·2
Middle of Eclipse			22	22·1
Last contact with Shadow			23	30·0
" " " Penumbra		8	0	41·7
Magnitude of Eclipse (Moon's diameter=1)	0·432			

The first contact with the Shadow takes place at 52° towards the E. of the N. point; the last contact at 27° towards the W. (for *Direct* image).

Date.	Star.	Mag.	Disap.	Angle.	Reap.	Angle.
Apr.			h m	°	h m	°
2	B.A.C. 2731	6½	9 20	97	10 30	288
7	46 Virginis	6	9 23	164	10 6	246
7	48 Virginis......	6	10 59	141	12 2	271
8	94 Virginis......	6	13 12	125	14 22	282
9	ξ^1 Libræ	6	7 55‡	71	8 38	330
11	29 Ophiuchi	6	13 16	134	14 19	254
14	57 Sagittarii	5½	14 56	73	16 9	282
25	48 Tauri........	6	9 0	132	9 36‡	215
29	3 Cancri	6	12 13	99	13 4*	281
30	54 Cancri	6½	9 36	143	10 27	249
30	o^1 Cancri........	6	12 25	47	12 53	342
May						
4	γ^1 Virginis	2½	12 25	66	13 8	341
4	B.A.C. 4277	6	13 40	28	13 46	375
12	π Capricorni	5	15 35	73	16 57	266
18	29 Ceti	6½	14 52‡	79	15 50	241
29	45 Leonis	6	8 37	142	9 34	262
29	ρ Leonis	4	11 10	131	12 2	268
30	σ Leonis	4	7 46	41	8 6	9
June						
2	94 Virginis......	6	8 29	197	8 39	214
4	49 Libræ	5½	7 55	167	8 30	232
5	29 Ophiuchi	6	8 52	93	9 59	297
6	B.A.C. 6081	6	8 40	126	9 39	254
10	45 Capricorni....	6	11 49	103	12 53	235
July						
1	η Libræ	6	9 23	166	10 4	231
6	B.A.C. 7053	5½	9 49	112	10 53	237
6	o Capricorni	5½	9 49	111	10 54	237
8	42 Aquarii	6	12 48	115	13 45	206
16	85 Tauri........	6	13 5‡	116	13 45	217
16	α Tauri	1	15 16	1	15 33	328
17	115 Tauri	6	13 50‡	73	14 40	266
25	B.A.C. 4277	6	8 20	180	8 45	225
31	21 Sagittarii	5	12 23	105	13 29	249
Aug.						
5	70 Aquarii	6	13 14	139	13 38	173
7	B.A.C. 81	6½	15 53	100	16 57	206
8	26 Ceti	6½	11 57	40	13 2	272
8	29 Ceti	6½	15 24	2	16 5	302
12	48 Tauri........	6	14 18	64	15 24	259
22	65 Virginis......	6	8 34	126	9 26‡	271
27	B.A.C. 6081	6	5 59	115	7 14	261
28	ξ^1 Sagittarii	6	6 54	130	7 56	232
31	45 Capricorni....	6	12 15	84	13 29	233
Sept.						
24	29 Sagittarii	6	10 43	34	11 24‡	314
25	*f* Sagittarii......	5	11 27	89	12 30‡	248

Date.	Star.	Mag.	Disap.	Angle.	Reap.	Angle.
Sept.			h m	°	h m	°
26	B.A.C. 7053	5½	5 35	84	6 55	259
26	o Capricorni	5½	5 36	84	6 55	260
26	υ Capricorni	5½	12 1	119	12 48‡	209
28	42 Aquarii......	6	10 14	121	11 1	192
Oct.						
1	15 Ceti	6½	13 9	3	13 50	302
6	75 Tauri........	6	10 45	38	11 39	287
6	θ^1 Tauri	4½	10 54	150	11 8	175
6	B.A.C. 1391	5	11 45	113	12 40	211
6	α Tauri	1	15 20	136	16 2	195
8	71 Orionis	5½	11 56	80	13 1	262
10	ζ^1 Cancri	4½	15 48	161	16 16	208
12	α Leonis........	1½	16 44	108	17 50	283
23	σ Capricorni	5½	8 18	88	9·29	243
24	θ Capricorni	4	4 32	81	5 52	254
26	70 Aquarii......	6	7 50	86	9 7	224
28	B.A.C. 81	6½	11 32	113	12 21	193
29	26 Ceti	6½	7 22	63	8 37	245
29	29 Ceti	6½	10 40	41	11 57	263
29	33 Ceti	6	12 58	13	13 44	297
29	35 Ceti	6½	43 54	63	15 3	252
31	μ Ceti..........	4	14 34	101	15 38	221
Nov.						
2	B.A.C. 1351	6½	16 19	358	16 30	341
2	75 Tauri........	6	18 41	132	19 21	215
6	g Geminorum....	5½	10 34	162	10 51	197
8	7 Leonis........	6½	10 30‡	56	11 8	321
8	ψ Leonis........	6	13 52	62	14 42	321
18	33 Sagittarii	5	4 23	156	4 50	197
18	ξ^2 Sagittarii	4	6 2	103	7 5	244
20	B.A.C. 7202	6	4 46	56	6 2	274
20	B.A.C. 7209	6½	5 35	30	6 32	298
20	19 Capricorni....	6	8 30	97	9 30‡	229
Dec.						
1	119 Tauri	5½	4 28‡	84	5 18	256
1	120 Tauri	6	5 0‡	108	5 46	231
5	7 Leonis........	6½	17 18	133	18 27	266
18	ι Capricorni	4½	5 58	100	6 59	220
27	75 Tauri........	6	6 26	87	7 35	235

‡ Star below the horizon. * Star setting.

The angles are reckoned from the true N. point towards the right of the Moon's inverted image, in the direction N., E., S., W.

PHENOMENA OF JUPITER'S SATELLITES, 1887

January.

d	h	m	
1	1	28	ii. Ec. D.
	6	19	ii. Oc. R.
	16	32	i. Ec. D.
	19	51	iii, Tr. I.
	19	52	i. Oc. R.
	21	48	iii. Tr. E.
2	14	49	i. Tr. I.
	17	1	i. Tr. E.
	22	47	ii. Tr. I.
3	1	23	ii. Tr. E.
	11	0	i. Ec. D.
	14	21	i. Oc. R.
4	9	18	i. Tr. I.
	11	30	i. Tr. E.
	14	44	ii. Ec. D.
	19	38	ii. Oc. R.
5	5	22	iii. Ec. D.
	5	29	i. Ec. D.
	7	24	iii. Ec. R.
	8	50	i. Oc. R.
	10	9	iii. Oc. D.
	12	5	iii. Oc. R.
6	3	47	i. Tr. I.
	5	59	i. Tr. E.
	12	7	ii. Tr. I.
	14	43	ii. Tr. E.
	23	57	i. Ec. D.
7	3	19	i. Oc. R.
	22	16	i. Tr. I.
8	0	28	i. Tr. E.
	4	1	ii. Ec. D.
	8	57	ii. Oc. R.
	18	25	i. Ec. D.
	21	48	i. Oc. R.
9	0	0	iii. Tr. I.
	1	54	iii. Tr. E.
	16	44	i. Tr. I.
	18	57	i. Tr. E.
10	1	27	ii. Tr. I.
	4	2	ii. Tr. E.
	12	54	i. Ec. D.
	16	17	i. Oc. R.
11	11	13	i. Tr. I.
	13	25	i. Tr. E.
	17	18	ii. Ec. D.
	22	15	ii. Oc. R.
12	7	22	i. Ec. D.
	9	19	iii. Ec. D.
	10	45	i. Oc. R.
	11	20	iii. Ec. R.
	14	17	iii. Oc. D.
	16	8	iii. Oc. R.

January (con.).

d	h	m	
13	5	42	i. Tr. I.
	7	54	i. Tr. E.
	14	46	ii. Tr. I.
	17	21	ii. Tr. E.
14	1	50	i. Ec. D.
	5	14	i. Oc. R.
15	0	10	i. Tr. I.
	2	22	i. Tr. E.
	6	34	ii. Ec. D.
	11	34	ii. Oc. R.
	20	19	i. Ec. D.
	23	42	i. Oc. R.
16	4	6	iii. Tr. I.
	5	55	iii. Tr. E.
	18	39	i. Tr. I.
	20	51	i. Tr. E.
17	4	5	ii. Tr. I.
	6	39	ii. Tr. E.
	14	47	i. Ec. D.
	18	11	i. Oc. R.
18	13	7	i. Tr. I.
	15	19	i. Tr. E.
	19	51	ii. Ec. D.
19	0	51	ii. Oc R.
	9	15	i. Ec. D.
	12	40	i. Oc. R.
	13	18	iii. Ec. D.
	15	17	iii. Ec. R.
	18	22	iii. Oc. D.
	20	9	iii. Oc. R.
20	7	36	i. Tr. I.
	9	48	i. Tr. E.
	17	24	ii, Tr. I.
	19	58	ii. Tr. E.
21	3	44	i. Ec. D.
	7	8	i. Oc. R.
22	2	4	i. Tr. I.
	4	16	i. Tr. E.
	9	8	ii. Ec. D.
	14	9	ii. Oc. R.
	22	12	i. Ec. D.
23	1	36	i. Oc. R.
	8	8	iii. Tr. I.
	9	52	iii. Tr. E.
	20	33	i. Tr. I.
	22	44	i. Tr. E.
24	6	42	ii. Tr. I.
	9	15	ii. Tr. E.
	16	40	i. Ec. D.
	20	5	i. Oc. R.
25	15	1	i. Tr. I.
	17	13	i. Tr. E.

January (con.).

d	h	m	
25	22	25	ii. Ec. D.
26	3	26	ii. Oc. R.
	11	9	i. Ec. D.
	14	33	i. Oc. R.
	17	16	iii. Ec. D.
	19	14	iii. Ec. R.
	22	23	iii. Oc. D.
27	0	5	iii. Oc. R.
	9	29	i. Tr. I.
	11	41	i. Tr. E.
	19	59	ii. Tr. I.
	22	32	ii. Tr. E.
28	5	37	i. Ec. D.
	9	1	i. Oc. R.
29	3	57	i. Tr. I.
	6	9	i. Tr. E.
	11	42	ii. Ec. D.
	16	42	ii. Oc. R.
30	0	5	i. Ec. D.
	3	29	i. Oc. R.
	12	6	iii. Tr. I.
	13	46	iii. Tr. E.
	22	26	i. Tr. I.
31	0	37	i. Tr. E.
	9	16	ii. Tr. I.
	11	48	ii. Tr. E.
	18	34	i. Ec. D.
	21	57	i. Oc. R.

February.

1	16	54	i. Tr. I.
	19	5	i. Tr. E.
2	0	59	ii. Ec. D.
	5	58	ii. Oc. R.
	13	2	i. Ec. D.
	16	25	i. Oc. R.
	21	14	iii. Ec. D.
	23	11	iii. Ec. R.
3	2	19	iii. Oc. D.
	3	57	iii. Oc. R.
	11	22	i. Tr. I.
	13	33	i. Tr. E.
	22	32	ii. Tr. I.
4	1	5	ii. Tr. E.
	7	30	i. Ec. D.
	10	53	i. Oc. R.
5	5	49	i. Tr. I.
	8	1	i. Tr. E.
	14	15	ii. Ec. D.
	19	13	ii. Oc. R.
6	1	58	i. Ec. D.

Februar

d	h	m
6	5	21
	16	0
	17	35
7	0	17
	2	29
	11	48
	14	20
	20	27
	23	49
8	18	45
	20	56
9	3	33
	8	28
	14	55
	18	17
10	1	11
	3	7
	6	11
	7	44
	13	13
	15	24
11	1	3
	3	35
	9	23
	12	44
12	7	40
	9	52
	16	50
	21	43
13	3	52
	7	12
	19	50
	21	21
14	2	8
	4	19
	14	17
	16	49
	22	20
15	1	39
	20	36
	22	47
16	6	7
	10	56
	16	48
	20	7
17	5	8
	7	4
	9	58
	11	26
	15	3
	17	14
18	3	31

February (con.).

d	h	m	
18	6	2	ii. Tr. E.
	11	17	i. Ec. D.
	14	34	i. Oc. R.
19	9	30	i. Tr. I.
	11	42	i. Tr. E.
	19	24	ii. Ec. D.
20	0	10	ii. Oc. R.
	5	45	i. Ec. D.
	9	1	i. Oc. R.
	23	35	iii. Tr. I.
21	1	1	iii. Tr. E.
	3	58	i. Tr. I.
	6	9	i. Tr. E.
	16	44	ii. Tr. I.
	19	15	ii. Tr. E.
22	0	13	i. Ec. D.
	3	29	i. Oc. R.
	22	25	i. Tr. I.
23	0	36	i. Tr. E.
	8	41	ii. Ec. D.
	13	23	ii. Oc. R.
	18	41	i. Ec. D.
	21	56	i. Oc. R.
24	9	6	iii. Ec. D.
	11	0	iii. Ec. R.
	13	40	iii. Oc. D.
	15	4	iii. Oc. R.
	16	52	i. Tr. I.
	19	3	i. Tr. E.
25	5	57	ii. Tr. I.
	8	28	ii. Tr. E.
	13	10	i. Ec. D.
	16	23	i. Oc. R.
26	11	19	i. Tr. I.
	13	30	i. Tr. E.
	21	58	ii. Ec. D.
27	2	35	ii. Oc. R.
	7	38	i. Ec. D.
	10	50	i. Oc. R.
28	3	16	iii. Tr. I.
	4	38	iii. Tr. E.
	5	46	i. Tr. I.
	7	57	i. Tr. E.
	19	9	ii. Tr. I.
	21	39	ii. Tr. E.

March.

d	h	m	
1	2	6	i. Ec. D.
	5	17	i. Oc. R.
2	0	13	i. Tr. I.
	2	24	i. Tr. E.
	11	16	ii. Ec. D.
	15	47	ii. Oc. R.
	20	35	i. Ec. D.
	23	44	i. Oc. R.
3	13	4	iii. Ec. D.
	14	57	iii. Ec. R.

March (con.).

d	h	m	
3	17	18	iii. Oc. D.
	18	38	iii. Oc. R.
	18	40	i. Tr. I.
	20	51	i. Tr. E.
4	8	21	ii. Tr. I.
	10	51	ii. Tr. E.
	15	3	i. Ec. D.
	18	11	i. Oc. R.
5	13	7	i. Tr. I.
	15	18	i. Tr. E.
6	0	33	ii. Ec. D.
	4	59	ii. Oc. R.
	9	31	i. Ec. D.
	12	38	i. Oc. R.
7	6	51	iii. Tr. I.
	7	34	i. Tr. I.
	8	10	iii. Tr. E.
	9	45	i. Tr. E.
	21	32	ii. Tr. I.
8	0	1	ii. Tr. E.
	4	0	i. Ec. D.
	7	4	i. Oc. R.
9	2	1	i. Tr. I.
	4	12	i. Tr. E.
	13	50	ii. Ec. D.
	18	10	ii. Oc. R.
	22	28	i. Ec. D.
10	1	31	i. Oc. R.
	17	2	iii. Ec. D.
	18	54	iii. Ec. R.
	20	27	i. Tr. I.
	20	51	iii. Oc. D.
	22	9	iii. Oc. R.
	22	38	i. Tr. E.
11	10	42	ii. Tr. I.
	13	12	ii. Tr. E.
	16	56	i. Ec. D.
	19	58	i. Oc. R.
12	14	54	i. Tr. I
	17	5	i. Tr. E.
13	3	8	ii. Ec. D.
	7	20	ii. Oc. R.
	11	25	i. Ec. D.
	14	24	i. Oc. R.
14	9	21	i. Tr. I.
	10	21	iii. Tr. I.
	11	32	i. Tr. E.
	11	38	iii. Tr. E.
	23	52	ii. Tr. I.
15	2	21	ii. Tr. E.
	5	53	i. Ec. D.
	8	51	i. Oc. R.
16	3	47	i. Tr. I.
	5	58	i. Tr. E.
	16	26	ii. Ec. D.
	20	30	ii. Oc. R.
17	0	21	i. Ec. D.
	3	17	i. Oc. R.

March (con.).

d	h	m	
17	21	0	iii. Ec. D.
	22	14	i. Tr. I.
	22	51	iii. Ec. R.
18	0	20	iii. Oc. D.
	0	25	i. Tr. E.
	1	36	iii. Oc. R.
	13	1	ii. Tr. I.
	15	30	ii. Tr. E.
	18	50	i. Ec. D.
	21	44	i. Oc. R.
19	16	40	i. Tr. I.
	18	51	i. Tr. E.
20	5	43	ii. Ec. D.
	9	40	ii. Oc. R.
	13	18	i. Ec. D.
	16	10	i. Oc. R.
21	11	7	i. Tr. I.
	13	18	i. Tr. E.
	13	47	iii. Tr. I.
	15	4	iii. Tr. E.
22	2	9	ii. Tr. I.
	4	39	ii. Tr. E.
	7	46	i. Ec. D.
	10	36	i. Oc. R.
23	5	33	i. Tr. I.
	7	44	i. Tr. E.
	19	1	ii. Ec. D.
	22	49	ii. Oc. R.
24	2	15	i. Ec. D.
	5	2	i. Oc. R.
	23	59	i. Tr. I.
25	0	58	iii. Ec. D.
	2	10	i. Tr. E.
	2	49	iii. Ec. R.
	3	44	iii. Oc. D.
	5	0	iii. Oc. R.
	15	18	ii. Tr. I.
	17	47	ii. Tr. E.
	20	43	i. Ec. D.
	23	29	i. Oc. R.
26	18	25	i. Tr. I.
	20	36	i. Tr. E.
27	8	18	ii. Ec. D.
	11	58	ii. Oc. R.
	15	11	i. Ec. D.
	17	55	i. Oc. R.
28	12	52	i. Tr. I.
	15	3	i. Tr. E.
	17	9	iii. Tr. I.
	18	26	iii. Tr. E.
29	4	25	ii. Tr. I.
	6	55	ii. Tr. E.
	9	40	i. Ec. D.
	12	21	i. Oc. R.
30	7	18	i. Tr. I.
	9	29	i. Tr. E.
	21	36	ii. Ec. D.
31	1	6	ii. Oc. R.

March (con.).

d	h	m	
31	4	8	i. Ec. D.
	6	47	i. Oc. R.

April.

d	h	m	
1	1	44	i. Tr. I.
	3	55	i. Tr. E.
	4	56	iii. Ec. D.
	6	45	iii. Ec. R.
	7	4	iii. Oc. D.
	8	21	iii. Oc. R.
	17	33	ii. Tr. I.
	20	2	ii. Tr. E.
	22	36	i. Ec. D.
2	1	13	i. Oc. R.
	20	10	i. Tr. I.
	22	21	i. Tr. E.
3	10	54	ii. Ec. D.
	14	15	ii. Oc. R.
	17	5	i. Ec. D.
	19	39	i. Oc. R.
4	14	36	i. Tr. I.
	16	47	i. Tr. E.
	20	29	iii. Tr. I.
	21	48	iii. Tr. E.
5	6	40	ii. Tr. I.
	9	10	ii. Tr. E.
	11	33	i. Ec. D.
	14	5	i. Oc. R.
6	9	2	i. Tr. I.
	11	13	i. Tr. E.
7	0	12	ii. Ec. D.
	3	23	ii. Oc. R.
	6	2	i. Ec. D.
	8	31	i. Oc. R.
8	3	28	i. Tr. I.
	5	40	i. Tr. E.
	8	54	iii. Ec. D.
	11	41	iii. Oc. R.
	19	47	ii. Tr. I.
	22	17	ii. Tr. E.
9	0	30	i. Ec. D.
	2	57	i. Oc. R.
	21	54	i. Tr. I.
10	0	5	i. Tr. E.
	13	30	ii. Ec. D.
	16	31	ii. Oc. R.
	18	58	i. Ec. D.
	21	23	i. Oc. R.
11	16	20	i. Tr. I.
	18	32	i. Tr. E.
	23	46	iii. Tr. I.
12	1	7	iii. Tr. E.
	8	54	ii. Tr. I.
	11	24	ii. Tr. E.
	13	27	i. Ec. D.
	15	49	i. Oc. R.
13	10	46	i. Tr. I.

April (con.).

d	h	m	
13	12	57	i. Tr. E.
14	2	48	ii. Ec. D.
	5	39	ii. Oc. R.
	7	55	i. Ec. D.
	10	15	i. Oc. R.
15	5	12	i. Tr. I.
	7	24	i. Tr. E.
	12	52	iii. Ec. D.
	14	59	iii. Oc. R.
15	22	0	ii. Tr. I.
16	0	30	ii. Tr. E.
	2	24	i. Ec. D.
	4	41	i. Oc. R.
	23	38	i. Tr. I.
17	1	50	i. Tr. E.
	16	6	ii. Ec. D.
	18	47	ii. Oc. R.
	20	52	i. Ec. D.
	23	6	i. Oc. R.
18	18	4	i. Tr. I.
	20	16	i. Tr. E.
19	3	1	iii. Tr. I.
	4	26	iii. Tr. E.
	11	6	ii. Tr. I.
	13	37	ii. Tr. E.
	15	21	i. Ec. D.
	17	32	i. Oc. R.
20	12	30	i. Tr. I.
	14	41	i. Tr. E.
21	5	24	ii. Oc. D.
	7	55	ii. Ec. R.
	9	47	i. Oc. D.
	11	57	i. Ec. R.
22	6	56	i. Tr. I.
	9	8	i. Tr. E.
	16	50	iii. Oc. D.
	18	37	iii. Ec. R.
23	0	13	ii. Tr. I.
	2	43	ii. Tr. E.
	4	13	i. Oc. D.
	6	25	i. Ec. R.
24	1	22	i. Tr. I.
	3	34	i. Tr. E.
	18	31	ii. Oc. D.
	21	13	ii. Ec. R.
	22	39	i. Oc. D.
25	0	53	i. Ec. R.
	19	48	i. Tr. I.
	22	0	i. Tr. E.
26	6	15	iii. Tr. I.
	7	45	iii. Tr. E.
	13	19	ii. Tr. I.
	15	50	ii. Tr. E.
	17	4	i. Oc. D.
	19	22	i. Ec. R.
27	14	14	i. Tr. I.
	16	26	i. Tr. E.
28	7	39	ii. Oc. D.

April (con.).

d	h	m	
28	10	32	ii. Ec. R.
	11	30	i. Oc. D.
	13	50	i. Ec. R.
29	8	40	i. Tr. I.
	10	52	i. Tr. E.
	20	5	iii. Oc. D.
	22	35	iii. Ec. R.
30	2	25	ii. Tr. I.
	4	57	ii. Tr. E.
	5	56	i. Oc. D.
	8	19	i. Ec. R.

May.

d	h	m	
1	3	6	i. Tr. I.
	5	18	i. Tr. E.
	20	47	ii. Oc. D.
	23	49	ii. Ec. R.
2	0	22	i. Oc. D.
	2	47	i. Ec. R.
	21	33	i. Tr. I.
	23	44	i. Tr. E.
3	9	30	iii. Tr. I.
	11	5	iii. Tr. E.
	15	32	ii. Tr. I.
	18	4	ii. Tr. E.
	18	48	i. Oc. D.
	21	16	i. Ec. R.
4	15	59	i. Tr. I.
	18	11	i. Tr. E.
5	9	55	ii. Oc. D.
	13	8	ii. Ec. R.
	13	14	i. Oc. D.
	15	44	i. Ec. R.
6	10	25	i. Tr. I.
	12	37	i. Tr. E.
	23	20	iii. Oc. D.
7	2	33	iii. Ec. R.
	4	39	ii. Tr. I.
	7	11	ii. Tr. E.
	7	40	i. Oc. D.
	10	13	i. Ec. R.
8	4	51	i. Tr. I.
	7	3	i. Tr. E.
	23	3	ii. Oc. D.
9	2	7	i. Oc. D.
	2	26	ii. Ec. R.
	4	41	i. Ec. R.
	23	18	i. Tr. I.
10	1	29	i. Tr. E.
	12	47	iii. Tr. I.
	14	27	iii. Tr. E.
	17	46	ii. Tr. I.
	20	18	ii. Tr. E.
	20	33	i. Oc. D.
	23	10	i. Ec. R.
11	17	44	i. Tr. E.
	19	56	i. Tr. E.
12	12	12	ii. Oc. D.

Mag (con.).

d	h	m	
12	14	59	i. Oc. D.
	15	45	ii. Ec. R.
	17	38	i. Ec. R.
13	12	10	i. Tr. I.
	14	22	i. Tr. E.
14	2	38	iii. Oc. D.
	4	20	iii. Oc. R.
	4	47	iii. Ec. D.
	6	31	iii. Ec. R.
	6	53	ii. Tr. I.
	9	25	i. Oc. D.
	9	26	ii. Tr. E.
	12	7	i. Ec. R.
15	6	37	i. Tr. I.
	8	48	i. Tr. E.
16	1	21	ii. Oc. D.
	3	51	i. Oc. D.
	5	3	ii. Ec. R.
	6	35	i. Ec. R.
17	1	3	i. Tr. I.
	3	15	i. Tr. E.
	16	6	iii. Tr. I.
	17	51	iii. Tr. E.
	20	1	ii. Tr. I.
	22	18	i. Oc. D.
	22	34	ii. Tr. E.
18	1	4	i. Ec. R.
	19	29	i. Tr. I.
	21	41	i. Tr. E.
19	14	30	ii. Oc. D.
	16	44	i. Oc. D.
	18	22	ii. Ec. R.
	19	32	i. Ec. R.
20	13	56	i. Tr. I.
	16	8	i. Tr. E.
21	5	58	iii. Oc. D.
	7	45	iii. Oc. R.
	8	46	iii. Ec. D.
	9	9	ii. Tr. I.
	10	28	iii. Ec. R.
	11	10	i. Oc. D.
	11	42	ii. Tr. E.
	14	1	i. Ec. R.
22	8	23	i. Tr. I.
	10	35	i. Tr. E.
23	3	40	ii. Oc. D.
	5	37	i. Oc. D.
	7	40	ii. Ec. R.
	8	29	i. Ec. R.
24	2	49	i. Tr. I.
	5	1	i. Tr. E.
	19	29	iii. Tr. I.
	21	19	iii. Tr. E.
	22	17	ii. Tr. I.
25	0	3	i. Oc. D.
	0	51	ii. Tr. E.
	2	58	i. Ec. R.
	21	16	i. Tr. I.

May

d	h	m
25	23	28
26	16	50
	18	30
	20	59
	21	27
27	15	43
	17	55
28	9	21
	11	14
	11	26
	12	44
	12	57
	14	1
	14	26
	15	55
29	10	10
	12	22
30	6	1
	7	23
	10	17
	10	24
31	4	37
	6	49
	22	55

Ju

d	h	m
1	0	36
	0	50
	1	50
	3	10
	4	52
	23	4
2	1	16
	19	12
	20	17
	23	21
	23	36
3	17	31
	19	43
4	12	49
	13	46
	14	44
	14	46
	16	21
	16	43
	17	49
	18	24
5	11	58
	14	10
6	8	24
	9	11
	12	18
	12	54
7	6	25
	8	37
8	2	25
	2	56

June (con.).

d	h	m	
8	3	38	i. Oc. D.
	4	24	iii. Tr. E.
	5	32	ii. Tr. E.
	6	47	i. Ec. R.
9	0	52	i. Tr. I.
	3	5	i. Tr. E.
	21	36	ii. Oc. D.
	22	5	i. Oc. D.
10	1	15	i. Ec. R.
	2	13	ii. Ec. R.
	19	20	i. Tr. I.
	21	32	i. Tr. E.
11	16	7	ii. Tr. I.
	16	21	iii. Oc. D.
	16	32	i. Oc. D.
	18	22	iii. Oc. R.
	18	43	ii. Tr. E.
	19	44	i. Ec. R.
	20	42	iii. Ec. D.
	22	22	iii. Ec. R.
12	13	47	i. Tr. I.
	16	0	i. Tr. E.
13	10	49	ii. Oc. D.
	11	0	i. Oc. D.
	14	12	i. Ec. R.
	15	31	ii. Ec. R.
14	8	15	i. Tr. I.
	10	27	i. Tr. E.
15	5	19	ii. Tr. I.
	5	27	i. Oc. D.
	6	0	iii. Tr. I.
	7	55	ii. Tr. E.
	8	2	iii. Tr. E.
	8	41	i. Ec. R.
16	2	42	i. Tr. I.
	4	55	i. Tr. E.
	23	54	i. Oc. D.
17	0	3	ii. Oc. D.
	3	10	i. Ec. R.
	4	50	ii. Ec. R.
	21	10	i. Tr. I.
	23	22	i. Tr. E.
18	18	22	i. Oc. D.
	18	31	ii. Tr. i.
	19	58	iii. Oc. D.
	21	8	ii. Tr. E.
	21	38	i. Ec. R.
	22	2	iii. Oc. R.
19	0	42	iii. Ec. D.
	2	21	iii. Ec. R.
	15	37	i. Tr. I.
	17	50	i. Tr. E.
20	12	49	i. Oc. D.
	13	17	ii. Oc. D.
	16	7	i. Ec. R.
	18	9	ii. Ec. R.
1	10	5	i. Tr. I.

June (con.).

d	h	m	
21	12	18	i. Tr. E.
22	7	17	i. Oc. D.
	7	44	ii. Tr. I.
	9	39	iii. Tr. I.
	10	21	ii. Tr. E.
	10	36	i. Ec. R.
	11	45	iii. Tr. E.
23	4	33	i. Tr. I.
	6	46	i. Tr. E.
24	1	45	i. Oc. D.
	2	31	ii. Oc. D.
	5	4	i. Ec. R.
	7	28	ii. Ec. R.
	23	2	i. Tr. I.
25	1	15	i. Tr. E.
	20	12	i. Oc. D.
	20	58	ii. Tr. I.
	23	33	i. Ec. R.
	23	34	ii. Tr. E.
	23	39	iii. Oc. D.
26	1	47	iii. Oc. R.
	4	41	iii. Ec. D.
	6	20	iii. Ec. R.
	17	28	i. Tr. I.
	19	41	i. Tr. E.
27	14	40	i. Oc. D.
	15	46	ii. Oc. D.
	18	2	i. Ec. R.
	20	46	ii. Ec. R.
28	11	57	i. Tr. I.
	14	10	i. Tr. E.
29	9	8	i. Oc. D.
	10	12	ii. Tr. I.
	12	30	i. Ec. R.
	12	49	ii. Tr. E.
	13	23	iii. Tr. I.
	15	32	iii. Tr. E.
30	6	25	i. Tr. I.
	8	38	i. Tr. E.

July.

d	h	m	
1	3	36	i. Oc. D.
	5	2	ii. Oc. D.
	6	59	i. Ec. R.
	10	5	ii. Ec. R.
2	0	53	i. Tr. I.
	3	6	i. Tr. E.
	22	4	i. Oc. D.
	23	26	ii. Tr. I.
3	1	27	i. Ec. R.
	2	4	ii. Tr. E.
	3	26	iii. Oc. D.
	5	36	iii. Oc. R.
	8	40	iii. Ec. D.
	10	18	iii. Ec. R.
	19	21	i. Tr. I.

July (con.).

d	h	m	
3	21	34	i. Tr. E.
4	16	32	i. Oc. D.
	18	19	ii. Oc. D.
	19	56	i. Ec. R.
	23	23	ii. Ec. R.
5	13	49	i. Tr. I.
	16	2	i. Tr. E.
6	11	0	i. Oc. D.
	12	42	ii. Tr. I.
	14	25	i. Ec. R.
	15	19	ii. Tr. E.
	17	12	iii. Tr. I.
	19	23	iii. Tr. E.
7	8	18	i. Tr. I.
	10	31	i. Tr. E.
8	5	29	i. Oc. D.
	7	35	ii. Oc. D.
	8	53	i. Ec. R.
	12	42	ii. Ec. R.
9	2	46	i. Tr. I.
	4	59	i. Tr. E.
	23	57	i. Oc. D.
10	1	57	ii. Tr. I.
	3	22	i. Ec. R.
	4	35	ii. Tr. E.
	7	16	iii. Oc. D.
	9	29	iii. Oc. R.
	12	39	iii. Ec. D.
	14	17	iii. Ec. R.
	21	15	i. Tr. I.
	23	28	i. Tr. E.
11	18	25	i. Oc. D.
	20	53	ii. Oc. D.
	21	51	i. Ec. R.
12	2	0	ii. Ec. R.
	15	43	i. Tr. I.
	17	56	i. Tr. E.
13	12	54	i. Oc. D.
	15	14	ii. Tr. I.
	16	19	i. Ec. R.
	17	52	ii. Tr. E.
	21	6	iii. Tr. I.
	23	19	iii. Tr. E.
14	10	12	i. Tr. I.
	12	25	i. Tr. E.
15	7	22	i. Oc. D.
	10	11	ii. Oc. D.
	10	48	i. Ec. R.
	15	19	ii. Ec. R.
16	4	40	i. Tr. I.
	6	54	i. Tr. E.
17	1	51	i. Oc. D.
	4	31	ii. Tr. I.
	5	17	i. Ec. R.
	7	9	ii. Tr. E.
	11	11	iii. Oc. D.
	13	25	iii. Oc. R.

July (con.).

d	h	m	
17	16	38	iii. Ec. D.
	18	15	iii. Ec. R.
	23	9	i. Tr. I.
18	1	22	i. Tr. E.
	20	19	i. Oc. D.
	23	29	ii. Oc. D.
	23	45	i. Ec. R.
19	4	38	ii. Ec. R.
	17	38	i. Tr. I.
	19	51	i. Tr. E.
20	14	48	i. Oc. D.
	17	48	ii. Tr. I.
	18	14	i. Ec. R.
	20	26	ii. Tr. E.
21	1	4	iii. Tr. I.
	3	18	iii. Tr. E.
	12	7	i. Tr. I.
	14	20	i. Tr. E.
22	9	17	i. Oc. D.
	12	43	i. Ec. R.
	12	48	ii. Oc. D.
	17	57	ii. Ec. R.
23	6	36	i. Tr. I.
	8	49	i. Tr. E.
24	3	46	i. Oc. D.
	7	6	ii. Tr. I.
	7	12	i. Ec. R.
	9	44	ii. Tr. E.
	15	10	iii. Oc. D.
	17	25	iii. Oc. R.
	20	37	iii. Ec. D.
	22	13	iii. Ec. R.
25	1	5	i. Tr. I.
	3	18	i. Tr. E.
	22	15	i. Oc. D.
26	1	40	i. Ec. R.
	2	7	ii. Oc. D.
	7	15	ii. Ec. R.
	19	34	i. Tr. I.
	21	47	i. Tr. E.
27	16	43	i. Oc. D.
	20	9	i. Ec. R.
	20	24	ii. Tr. I.
	23	3	ii. Tr. E.
28	5	5	iii. Tr. I.
	7	21	iii. Tr. E.
	14	3	i. Tr. I.
	16	16	i. Tr. E.
29	11	12	i. Oc. D.
	14	38	i. Ec. R.
	15	27	ii. Oc. D.
	20	34	ii. Ec. R.
30	8	32	i. Tr. I.
	10	45	i. Tr. E.
31	5	41	i. Oc. D.
	9	6	i. Ec. R.
	9	43	ii. Tr. I.

July (con.).

d	h	m	
31	12	22	ii. Tr. E.
	19	14	iii. Oc. D.
	21	30	iii. Oc. R.

August.

d	h	m	
1	0	37	iii. Ec. D.
	2	12	iii. Ec. R.
	3	1	i. Tr. I.
	5	14	i. Tr. E.
2	0	10	i. Oc. D.
	3	35	i. Ec. R.
	4	47	ii. Oc. D.
	9	52	ii. Ec. R.
	21	30	i. Tr. I.
	23	43	i. Tr. E.
3	18	40	i. Oc. D.
	22	4	i. Ec. R.
	23	3	ii. Tr. I.
4	1	41	ii. Tr. E.
	9	10	iii. Tr. I.
	11	26	iii. Tr. E.
	15	59	i. Tr. I.
	18	13	i. Tr. E.
5	13	9	i. Oc. D.
	16	32	i. Ec. R.
	18	8	ii. Oc. D.
	23	10	ii. Ec. R.
6	10	29	i. Tr. I.
	12	42	i. Tr. E.
7	7	38	i. Oc. D.
	11	1	i. Ec. R.
	12	23	ii. Tr. I.
	15	1	ii. Tr. E.
	23	20	iii. Oc. D.
8	1	37	iii. Oc. R.
	4	37	iii. Ec. D.
	4	58	i. Tr. I.
	6	11	iii. Ec. R.
	7	11	i. Tr. E.
9	2	7	i. Oc. D.
	5	30	i. Ec. R.
	7	29	ii. Oc. D.
	12	28	ii. Ec. R.
	23	27	i. Tr. I.
10	1	41	i. Tr. E.
	20	37	i. Oc. D.
	23	58	i. Ec. R.
11	1	43	ii. Tr. I.
	4	22	ii. Tr. E.
	13	18	iii. Tr. I.
	15	35	iii. Tr. E.
	17	57	i. Tr. I.
	20	10	i. Tr. E.
12	15	6	i. Oc. D.
	18	27	i. Ec. R.

August (con.).

d	h	m	
12	20	50	ii. Oc. D.
13	1	47	ii. Ec. R.
	12	26	i. Tr. I.
	14	40	i. Tr. E.
14	9	35	i. Oc. D.
	12	56	i. Ec. R.
	15	3	ii. Tr. I.
	17	14	ii. Tr. E.
15	3	31	iii. Oc. D.
	5	47	iii. Oc. R.
	6	56	i. Tr. I.
	8	36	iii. Ec. D.
	9	9	i. Tr. E.
	10	10	iii. Ec. R.
16	4	5	i. Oc. D.
	7	24	i. Ec. R.
	10	11	ii. Oc. D.
	15	5	ii. Ec. R.
17	1	25	i. Tr. I.
	3	39	i. Tr. E.
	22	34	i. Oc. D.
18	1	53	i. Ec. R.
	4	24	ii. Tr. I.
	7	3	ii. Tr. E.
	17	30	iii. Tr. I.
	19	46	iii. Tr. E.
	19	55	i. Tr. I.
	22	8	i. Tr. E.
19	17	4	i. Oc. D.
	20	22	i. Ec. R.
	23	33	ii. Oc. D.
20	4	24	ii. Ec. R.
	14	25	i. Tr. I.
	16	38	i. Tr. E.
21	11	33	i. Oc. D.
	14	50	i. Ec. R.
	17	46	ii. Tr. I.
	20	24	ii. Tr. E.
22	7	44	iii. Oc. D.
	8	54	i. Tr. I.
	10	0	iii. Oc. R.
	11	7	i. Tr. E.
	12	35	iii. Ec. D.
	14	9	iii. Ec. R.
23	6	3	i. Oc. D.
	9	19	i. Ec. R.
	12	56	ii. Oc. D.
	17	42	ii. Ec. R.
24	3	24	i. Tr. I.
	5	37	i. Tr. E.
25	0	33	i. Oc. D.
	3	48	i. Ec. R.
	7	8	ii. Tr. I.
	9	46	ii. Tr. E.
	21	44	iii. Tr. I.
	21	53	i. Tr. I.
26	0	1	iii. Tr. E.

August (con.).

d	h	m	
26	0	7	i. Tr. E.
	19	2	i. Oc. D.
	22	16	i. Ec. R.
27	2	18	ii. Oc. D.
	7	0	ii. Ec. R.
	16	23	i. Tr. I.
	18	37	i. Tr. E.
28	13	32	i. Oc. D.
	16	45	i. Ec. R.
	20	30	ii. Tr. I.
	23	8	ii. Tr. E.
29	10	53	i. Tr. I.
	11	59	iii. Oc. D.
	13	6	i. Tr. E.
	14	15	iii. Oc. R.
	16	34	iii. Ec. D.
	18	7	iii. Ec. R.
30	8	2	i. Oc. D.
	11	14	i. Ec. R.
	15	41	i. Oc. D.
	20	18	ii. Ec. R.
31	5	23	i. Tr. I.
	7	36	i. Tr. E.

September.

d	h	m	
1	2	32	i. Oc. D.
	5	42	i. Ec. R.
	9	52	ii. Tr. I.
	12	30	ii. Tr. E.
	23	53	i. Tr. I.
2	2	2	iii. Tr. I.
	2	6	i. Tr. E.
	4	18	iii. Tr. E.
	21	1	i. Oc. D.
3	0	11	i. Ec. R.
	5	4	ii. Oc. D.
	9	36	ii. Ec. R.
	18	23	i. Tr. I.
	20	36	i. Tr. E.
4	15	31	i. Oc. D.
	18	40	i. Ec. R.
	23	15	ii. Tr. I.
5	1	53	ii. Tr. E.
	12	52	i. Tr. I.
	15	6	i. Tr. E.
	16	17	iii. Oc. D.
	18	33	iii. Oc. R.
	20	33	iii. Ec. D.
	22	5	iii. Ec. R.
6	10	1	i. Oc. D.
	13	9	i. Ec. R.
	18	27	ii. Oc. D.
	22	54	ii. Ec. R.
7	7	23	i. Tr. I.
	9	36	i. Tr. E.

Septemb

d	h	m
8	4	31
	7	37
	12	38
	15	16
9	1	52
	4	6
	6	21
	8	37
	23	1
10	2	6
	7	50
	12	13
	20	22
	22	36
11	17	31
	20	34
12	2	1
	4	39
	14	52
	17	6
	20	37
	22	52
13	0	32
	2	4
	12	1
	15	3
	21	14
14	1	30
	9	22
	11	36
15	6	31
	9	32
	15	25
	18	2
16	3	52
	6	6
	10	43
	12	57
17	1	1
	4	1
	10	38
	14	48
	22	23
18	0	36
	19	31
	22	29
19	4	48
	7	26
	16	53
	19	6
20	1	0
	3	14
	4	31
	6	2
	14	1
	16	58
21	0	2

September (con.).

h	m	
4	6	ii. Ec. R.
11	23	i. Tr. I.
13	36	i. Tr. E.
8	31	i. Oc. D.
11	26	i. Ec. R.
18	12	ii. Tr. I.
20	50	ii. Tr. E.
5	53	i. Tr. I.
8	6	i. Tr. E.
15	6	iii. Tr. I.
17	19	iii. Tr. E.
3	1	i. Oc. D.
5	55	i. Ec. R.
13	28	ii. Oc. D.
17	24	ii. Ec. R.
0	23	i. Tr. I.
2	37	i. Tr. E.
21	32	i. Oc. D.
0	24	i. Ec. R.
7	37	ii. Tr. I.
10	14	ii. Tr. E.
18	53	i. Tr. I.
21	7	i. Tr. E.
5	24	iii. Oc. D.
7	37	iii. Oc. R.
8	30	iii. Ec. D.
10	2	iii. Ec. R.
16	2	i. Oc. D.
18	52	i. Ec. R.
2	50	ii. Oc. D.
6	42	ii. Ec. R.
13	23	i. Tr. I.
15	37	i. Tr. E.
10	32	i. Oc. D.
13	21	i. Ec. R.
21	1	ii. Tr. I.
23	38	ii. Tr. E.
7	53	i. Tr. I.
10	7	i. Tr. E.
19	30	iii. Tr. I.
21	42	iii. Tr. E.

December.

d	h	m	
2	4	23	i. Ec. D.
	6	57	i. Oc. R.
	22	34	ii. Tr. I.
3	1	7	ii. Tr. E.
	2	2	i. Tr. I.
	4	15	i. Tr. E.
	22	51	i. Ec. D.
4	1	27	i. Oc. R.
	11	40	iii. Tr. I.
	13	37	iii. Tr. E.
	16	44	ii. Ec. D.
	20	5	ii. Oc. R.
	20	32	i. Tr. I.
	22	45	i. Tr. E.
5	17	20	i. Ec. D.
	19	57	i. Oc. R.
6	11	59	ii. Tr. I.
	14	31	ii. Tr. E.
	15	3	i. Tr. I.
	17	15	i. Tr. E.
7	11	48	i. Ec. D.
	14	27	i. Oc. R.
8	0	16	iii. Ec. D.
	1	46	iii. Ec. R.
	2	2	iii. Oc. D.
	3	58	iii. Gc. R.
	6	1	ii. Ec. D.
	9	28	ii. Oc. R.
	9	33	i. Tr. I.
	11	45	i. Tr. E.
9	6	17	i. Ec. D.
	8	58	i. Oc. R.
10	1	24	ii. Tr. I.
	3	56	ii. Tr. E.
	4	3	i. Tr. I.
	6	15	i. Tr. E.
11	0	45	i. Ec. D.
	3	28	i. Oc. R.
	16	7	iii. Tr. I.
	18	1	iii. Tr. E.
	19	18	ii. Ec. D.
	22	33	i. Tr. I.

December (con.).

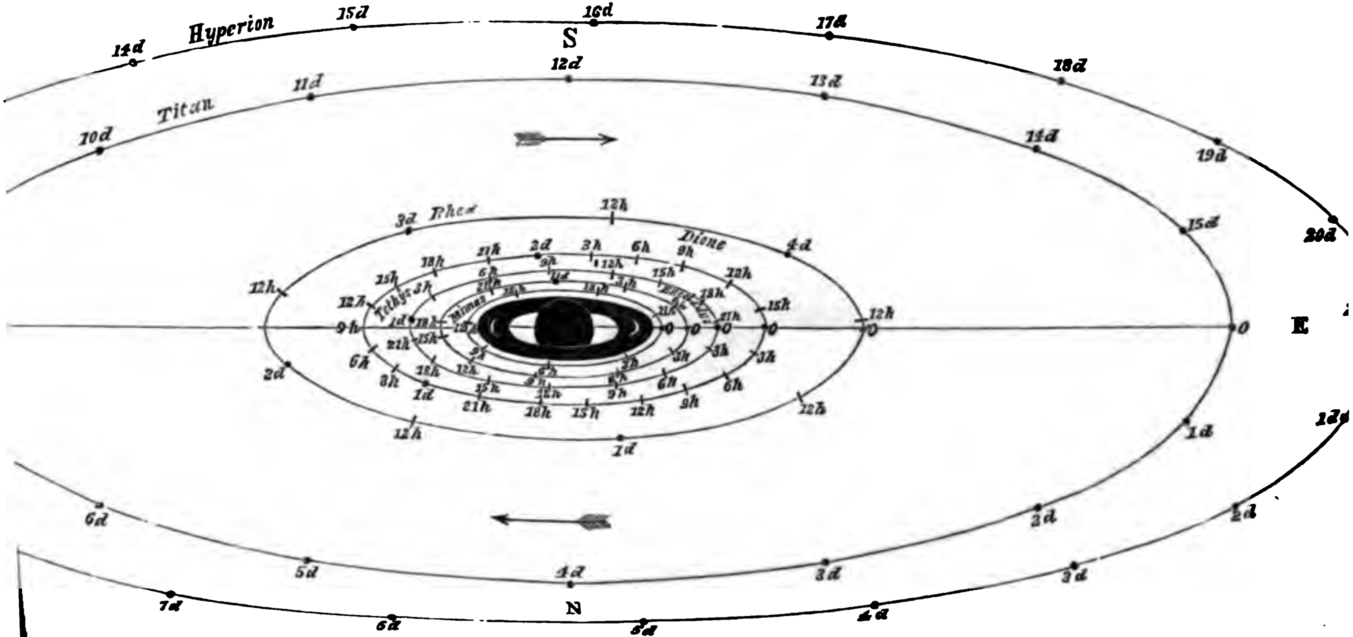
d	h	m	
11	22	51	ii. Oc. R.
12	0	45	i. Tr. E.
	19	14	i. Ec. D.
	21	58	i. Oc. R.
13	14	48	ii. Tr. I.
	17	3	i. Tr. I.
	17	20	ii. Tr. E.
	19	15	i. Tr. E.
14	13	42	i. Ec. D.
	16	28	i. Oc. R.
15	4	14	iii. Ec. D.
	5	43	iii. Ec. R.
	6	28	iii. Oc. D.
	8	22	iii. Oc. R.
	8	35	ii. Ec. D.
	11	33	i. Tr. i.
	12	14	ii. Oc. R.
	13	45	i. Tr. E.
16	8	11	i. Ec. D.
	10	58	i. Oc. R.
17	4	13	ii. Tr. I.
	6	3	i. Tr. I.
	6	45	ii. Tr. E.
	8	15	i. Tr. E.
18	2	39	i. Ec. D.
	5	28	i. Oc. R.
	20	32	iii. Tr. I.
	21	51	ii. Ec. D.
	22	25	iii. Tr. E.
19	0	32	i. Tr. I.
	1	37	ii. Oc. R.
	2	45	i. Tr. E.
	21	8	i. Ec. D.
	23	58	i. Oc. R.
20	17	37	ii. Tr. I.
	19	2	i. Tr. I.
	20	9	ii. Tr. E.
	21	15	i. Tr. E.
21	15	36	i. Ec. D.
	18	28	i. Oc. R.
22	8	12	iii. Ec. D.
	9	41	iii. Ec. R.

December (con.).

d	h	m	
22	10	53	iii. Oc. D.
	11	8	ii. Ec. D.
	12	45	iii. Oc. R.
	13	32	i. Tr. I.
	15	0	ii. Oc. R.
	15	45	i. Tr. E.
23	10	5	i. Ec. D.
	12	58	i. Oc. R.
24	7	2	ii. Tr. I.
	8	2	i. Tr. I.
	9	33	ii. Tr. E.
	10	15	i. Tr. E.
25	4	33	i. Ec. D.
	7	28	i. Oc. R.
26	0	25	ii. Ec. D.
	0	56	iii. Tr. I.
	2	32	i. Tr. I.
	2	47	iii. Tr. E.
	4	22	ii. Oc. R
	4	44	i. Tr. E.
	23	1	i. Ec. D.
27	1	58	i. Oc. R.
	20	25	ii. Tr. I.
	21	2	i. Tr. I.
	22	57	ii. Tr. E.
	23	14	i. Tr. E.
28	17	30	i. Ec. D.
	20	28	i. Oc. R.
29	12	10	iii. Ec. D.
	13	39	iii. Ec. R.
	13	41	ii. Ec. D.
	15	17	iii. Oc. D.
	15	31	i. Tr. I.
	17	6	iii. Oc. R.
	17	44	i. Tr. E.
	17	44	ii. Oc. R.
30	11	58	i. Ec. D.
	14	58	i. Oc. R.
31	9	50	ii. Tr. I.
	10	1	i. Tr. I.
	12	14	i. Tr. E.
	12	21	ii. Tr. E.

Satellites I. and II. *disappear* at eclipse on the *p* side of the planet from January 1 to April 20, the distance between the satellite and the planet at the time of the disappearance of the former becoming smaller at each successive eclipse. Both satellites *disappear* on the *p* side also throughout December, but *reappear* on the *f* side from April 20 to the end of October. Satellite III. both *disappears* and *reappears p* from January 1 to April 1, and throughout December. The *disappearance* only is seen *p* from April 8 to April 15. The *reappearance* only is seen *f* from April 22 to May 7; and from May 14 to the end of October the satellite both *disappears* and *reappears* on the following side of the planet. Satellite IV. does not suffer occultation or eclipse, nor does it transit across the disk of Jupiter at any time throughout the year.

NT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, as seen in an Inverting Telescope.



the diagram show the direction of the motion of the Satellites. The figures indicate the interval from the time of last East Elongation.

SATELLITES OF SATURN.

Greenwich Mean Times of East Elongations.

MIMAS.

—In the case of Mimas, which can usually be only seen at elongation, the f those elongations only, both East and West, which are visible at Green- e given.

February.		March.		April.		October.		November.		December.	
d	h	d	h	d	h	d	h	d	h	d	h
1	13·3 E.	1	8·5 W.	2	9·6 W.	3	16·9 E.	4	18·0 E.	3	11·9 W.
2	12·0 E.	2	7·1 W.	3	8·2 W.	4	15·5 E.	5	16·7 E.	5	9·1 W.
3	10·6 E.	4	15·7 E.	7	14·1 E.	5	14·1 E.	6	15·3 E.	8	16·3 E.
4	9·2 E.	13	14·6 W.	9	11·3 E.	6	12·7 E.	8	12·5 E.	9	14·9 E.
12	9·4 W.	14	13·3 W.	10	9·9 E.	12	15·8 W.	9	11·1 E.	10	13·5 E.
13	8·0 W.	15	11·9 W.	11	8·5 E.	13	14·4 W.	12	18·3 W.	11	12·1 E.
14	6·7 W.	16	10·5 W.	16	12·9 W.	14	13·0 W.	13	16·9 W.	12	10·7 E.
15	16·6 E.	17	9·1 W.	17	11·5 W.	15	11·6 W.	14	15·5 W.	13	9·3 E.
16	15·2 E.	18	7·8 W.	18	10·1 W.	19	17·4 E.	15	14·1 W.	15	17·9 W.
17	13·8 E.	21	14·9 E.	19	8·7 W.	20	16·1 E.	16	12·7 W.	16	16·5 W.
18	12·5 E.	22	13·5 E.	25	11·8 E.	21	14·8 E.	17	11·3 W.	17	15·1 W.
19	11·1 E.	23	12·1 E.	26	10·4 E.	22	13·4 E.	18	10·0 W.	18	13·8 W.
20	9·7 E.	24	10·7 E.	27	9·0 E.	23	12·0 E.	20	18·5 E.	19	12·4 W.
21	8·4 E.	25	9·3 E.			27	17·8 W.	21	17·2 E.	20	11·0 W.
22	7·0 E.	26	8·0 E.			28	16·4 W.	22	15·8 E.	21	9·6 W.
24	15·5 W.	30	13·7 W.			29	15·0 W.	23	14·4 E.	23	18·2 E.
25	14·1 W.	31	12·4 W.					24	13·1 E.	24	16·8 E.
26	12·7 W.							25	11·7 E.	25	15·4 E.
27	11·3 W.							26	10·3 E.	26	14·0 E.
28	9·9 W.							27	8·9 E.	27	12·6 E.
										28	11·2 E.

ENCELADUS.

February.		March.		April.		October.		November.		December.	
d	h	d	h	d	h	d	h	d	h	d	h
2	4·2	1	13·8	2	2·1	1	9·9	1	22·3	2	1·8
3	13·1	2	22·6	3	11·0	2	18·8	3	7·2	3	10·7
4	22·0	4	7·5	4	19·9	4	3·6	4	16·1	4	19·6
6	6·9	5	16·3	6	4·8	5	12·8	6	1·0	6	4·4
7	15·7	7	1·2	7	13·7	6	21·4	7	9·9	7	13·3
9	0·6	8	10·1	8	22·6	8	6·3	8	18·7	8	22·2
10	9·5	9	19·0	10	7·5	9	15·2	10	3·6	10	7·1
11	18·4	11	3·9	11	16·4	11	0·1	11	12·5	11	16·0
13	3·3	12	12·8	13	1·3	12	8·9	12	21·4	13	0·8
14	12·1	13	21·7	14	10·2	13	17·9	14	6·3	14	9·7
15	21·0	15	6·6	15	19·1	15	2·7	15	15·2	15	18·6
17	5·8	16	15·5	17	3·9	16	11·6	17	0·1	17	3·5
18	14·7	18	0·4	18	12·8	17	20·5	18	9·0	18	12·4
19	23·5	19	9·2	19	21·7	19	5·4	19	17·9	19	21·2
21	8·4	20	18·1	21	6·6	20	14·3	21	2·8	21	6·1
22	17·3	22	3·0	22	15·5	21	23·2	22	11·6	22	15·0
24	2·2	23	11·9	24	0·4	23	8·1	23	20·5	23	23·9
25	11·1	24	20·8	25	9·3	24	17·0	25	5·4	25	8·8
26	20·0	26	5·7	26	18·2	26	1·8	26	14·3	26	17·6
28	4·9	27	14·6	28	3·0	27	10·7	27	23·2	28	2·5
		28	23·5	29	11·9	28	19·6	29	8·0	29	11·3
		30	8·4	30	20·8	30	4·5	30	16·9	30	20·2
		31	17·2			31	13·4				

Greenwich Mean Times of East Elongations.

TETHYS.

January.		February.		March.		April.		October.		November.		December.	
d	h	d	h	d	h	d	h	d	h	d	h	d	h
1	7·4	2	9·4	2	16·7	1	21·6	2	3·1	1	8·1	1	13·1
3	4·7	4	6·6	4	14·0	3	18·9	4	0·4	3	5·4	3	10·3
5	2·0	6	3·9	6	11·3	5	16·2	5	21·7	5	2·7	5	7·6
6	23·3	8	1·2	8	8·7	7	13·5	7	19·0	7	0·0	7	4·9
8	20·6	9	22·5	10	5·9	9	10·8	9	16·3	8	21·4	9	2·2
10	17·9	11	19·8	12	3·2	11	8·1	11	13·7	10	18·7	10	23·6
12	15·2	13	17·1	14	0·5	13	5·5	13	11·0	12	16·0	12	20·9
14	12·5	15	14·4	15	21·8	15	2·8	15	8·3	14	13·3	14	18·2
16	9·8	17	11·7	17	19·1	17	0·1	17	5·6	16	10·6	16	15·5
18	7·0	19	9·0	19	16·4	18	21·4	19	2·9	18	7·9	18	12·8
20	4·3	21	6·2	21	13·7	20	18·7	21	0·3	20	5·2	20	10·1
22	1·6	23	3·5	23	11·0	22	16·0	22	21·6	22	2·5	22	7·4
23	22·9	25	0·8	25	8·3	24	13·3	24	18·9	23	23·8	24	4·7
25	20·2	26	22·1	27	5·6	26	10·7	26	16·2	25	21·2	26	1·9
27	17·5	28	19·4	29	3·0	28	8·0	28	13·5	27	18·5	27	23·2
29	14·8			31	0·3	30	5·3	30	10·8	29	15·8	29	20·5
31	12·1											31	17·8

DIONE.

January.		February.		March.		April.		October.		November.		December.	
d	h	d	h	d	h	d	h	d	h	d	h	d	h
2	7·8	1	9·9	3	12·1	2	14·7	3	3·6	2	6·3	2	8·9
5	1·4	4	3·6	6	5·8	5	8·3	5	21·3	5	0·0	5	2·5
7	19·1	6	21·2	8	23·5	8	2·0	8	14·9	7	17·7	7	20·2
10	12·8	9	14·9	11	17·1	10	19·8	11	8·7	10	11·4	10	13·8
13	6·4	12	8·5	14	10·8	13	13·4	14	2·4	13	5·1	13	7·5
16	0·1	15	2·1	17	4·5	16	7·1	16	20·1	15	22·8	16	1·1
18	17·7	17	19·8	19	22·1	19	0·9	19	13·8	18	16·5	18	18·8
21	11·3	20	13·4	22	15·8	21	18·5	22	7·5	21	10·2	21	12·4
24	5·0	23	7·0	25	9·6	24	12·2	25	1·2	24	3·8	24	6·1
26	22·6	26	0·7	28	3·2	27	5·9	27	18·9	26	21·5	26	23·8
29	16·2	28	18·5	30	20·9	29	23·6	30	12·6	29	15·2	29	17·5

RHEA.

January.		February.		March.		April.		October.		November.		December.	
d	h	d	h	d	h	d	h	d	h	d	h	d	h
1	10·5	2	0·5	1	2·4	1	17·3	4	4·9	4	20·4	1	22·9
5	22·7	6	12·8	5	14·8	6	5·8	8	17·5	9	8·9	6	11·3
10	11·0	11	1·1	10	3·2	10	18·2	13	6·0	13	21·3	10	23·6
14	23·3	15	13·4	14	15·6	15	6·6	17	18·5	18	9·7	15	11·9
19	11·6	20	1·7	19	4·0	19	19·0	22	7·0	22	22·2	20	0·2
23	23·9	24	14·1	23	16·5	24	7·4	26	19·5	27	10·5	24	12·5
28	12·2			28	4·9	28	19·8	31	7·9			29	0·8

Geenwich Mean Times of East Elongations.

TITAN.

January.	February.	March.	April.	October.	November.	December.
d h	d h	d h	d h	d h	d h	d h
9 5·9	10 0·6	13 20·0	14 17·2	8 1·9	9 1·3	10 21·5
25 2·7	25 21·9	29 18·4	30 16·4	24 2·3	24 23·7	26 19·7

HYPERION.

January.	February.	March.	April.	October.	November.	December.
d h	d h	d h	d h	d h	d h	d h
6 7·1	17 15·7	10 20·4	1 1·7	10 23·7	1 8·3	13 21·4
11·2			22 12·0		22 15·5	

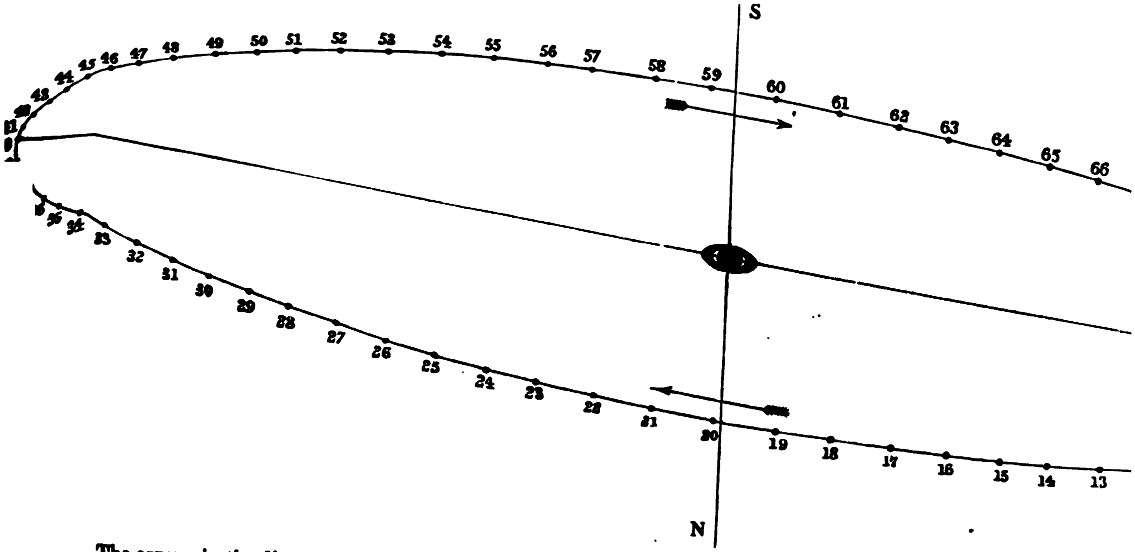
Apparent Elements of Saturn's Rings.

Greenwich Mean Noon.	Position-angle of Minor Axis.	Outer Ring. Maj. Axis.	Outer Ring. Min. Axis.	Inner Ring. Maj. Axis.	Inner Ring. Min. Axis.
	° ′	″	″	″	″
1886. Dec. 29...	352 36·6	46·42	18·45	30·87	12·27
1887. Jan. 18...	352 38·9	46·45	18·82	30·89	12·51
Feb. 7...	352 41·3	45·79	18·85	30·45	12·53
27...	352 43·2	44·57	18·54	29·64	12·33
Mar. 19...	352 43·7	43·07	17·99	28·64	11·96
April 8...	352 42·6	41·50	17·29	27·60	11·50
28...	352 40·3	40·06	16·53	26·64	11·00
Oct. 5...	352 34·5	39·83	13·03	26·49	8·66
25...	352 35·8	41·23	13·22	27·42	8·79
Nov. 14...	352 36·3	42·77	13·61	28·44	9·05
Dec. 4...	352 35·9	44·27	14·18	29·44	9·43
24...	352 34·7	45·49	14·86	30·25	9·89
1888. Jan. 13...	352 33·1	46·18	15·52	30·71	10·32

Greenwich Mean Noon.	Latitude above Plane of Ring. Of Earth.	Latitude above Plane of Ring. Of Sun.	Semi-major Axis of Orbit. Titan.	Semi-major Axis of Orbit. Iapetus.
	° ′	° ′	″	″
1886. Dec. 29...	23 25·4 S.	23 47·9 S.	208·8	608·6
1887. Jan. 18...	23 53·7 S.	23 38·0 S.	209·0	609·0
Feb. 7...	24 18·4 S.	23 27·7 S.	206·0	600·3
27...	24 35·1 S.	23 17·3 S.	200·5	584·4
Mar. 18...	24 41·6 S.	23 6·6 S.	193·7	564·6
April 8...	24 37·0 S.	22 55·7 S.	186·7	544·1
28...	24 22·6 S.	22 44·6 S.	180·2	525·2
Oct. 5...	19 5·6 S.	21 7·9 S.	179·2	522·2
25...	18 41·8 S.	20 54·9 S.	185·5	540·5
Nov. 14...	18 33·1 S.	20 41·7 S.	192·4	560·7
Dec. 4...	18 41·1 S.	20 28·3 S.	199·2	580·4
24...	19 44·4 S.	20 14·9 S.	204·6	596·4
1888. Jan. 13...	19 38·3 S.	20 1·1 S.	207·7	605·4

The semi-major axes of the orbits of Titan and Iapetus are given, as well as the position-angle of the minor axis of the ring, in order to furnish means for roughly inferring the distances and position-angles of the satellites from the diagrams given on p. 28 and p. 32.

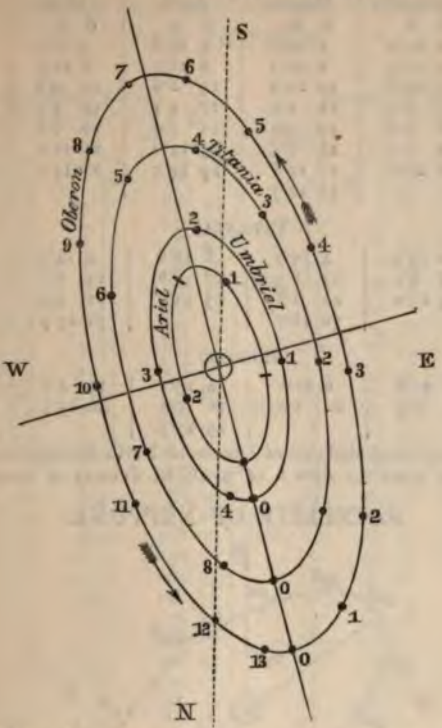
APPARENT ORBIT OF IAPETUS, as seen in an Inverting Teles



The arrows in the diagram show the direction of motion. The figures indicate the number of days from the time of

Dates of East Elongations of Iapetus:—1886, November 1; 1887, January 18, April 6, June 26, September

SATELLITES OF URANUS.



Apparent Orbits of the Satellites of Uranus, as seen in an inverting telescope.

The small circle in the above diagram represents the planet and is on the same scale as the orbits. The arrows show the direction of the motion of the satellites, and the figures indicate the number of days from the time of the last North Elongation.

Greenwich Mean Times of North Elongations.

Ariel.

January.		February.		March.		April.		May.		June.	
d	h	d	h	d	h	d	h	d	h	d	h
1	3·1	2	21·4	2	14·7	1	20·6	2	2·5	1	8·4
3	15·6	5	10·0	5	3·2	4	9·1	4	15·0	3	20·8
6	4·2	7	22·4	7	15·7	6	21·6	7	3·4	6	9·3
8	16·6	10	10·9	10	4·2	9	10·1	9	15·9	8	21·8
11	5·2	12	23·4	12	16·7	11	22·6	12	4·4	11	10·3
13	17·6	15	11·9	15	5·2	14	11·0	14	16·9	13	22·8
16	6·2	18	0·3	17	17·7	16	23·5	17	5·4	16	11·3
18	18·6	20	12·9	20	6·1	19	12·0	19	17·9	18	23·8
21	7·1	23	1·3	22	18·7	22	0·5	22	6·4	21	12·3
23	19·5	25	13·8	25	7·1	24	13·0	24	18·9	24	0·8
26	8·0	28	2·3	27	19·6	27	1·5	27	7·4	26	13·3
28	20·5			30	8·1	29	14·0	29	19·8	29	1·8
31	9·0										

UMBRIEL.

January.		February.		March.		April.		May.		June.	
d	h	d	h	d	h	d	h	d	h	d	h
3	13·7	1	13·9	2	14·1	4	17·7	3	17·9	1	18·1
7	17·2	5	17·4	6	17·5	8	21·1	7	21·3	5	21·6
11	20·6	9	20·8	10	20·9	13	0·6	12	0·9	10	1·1
16	0·1	14	0·2	15	0·4	17	4·1	16	4·3	14	4·6
20	3·6	18	3·7	19	3·9	21	7·6	20	7·8	18	8·0
24	7·0	22	7·2	23	7·4	25	11·0	24	11·2	22	11·5
28	10·4	26	10·6	27	10·8	29	14·5	28	14·7	26	14·9
				31	14·3					30	18·4

TITANIA.

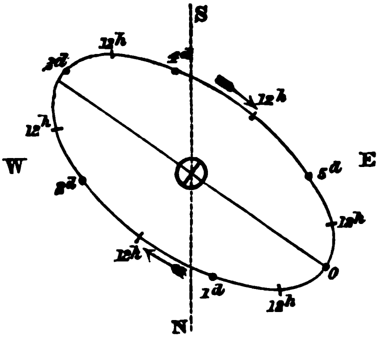
2	17·5	6	13·2	4	15·9	8	11·6	4	14·5	8	10·3
11	10·4	15	6·1	13	8·9	17	4·6	13	7·4	23	3·2
20	3·3	23	23·0	22	1·8	25	21·5	22	0·4	25	20·2
28	20·3			30	18·7			30	17·3		

OBERON.

12	0·7	7	22·8	6	21·0	2	19·1	13	4·5	9	2·7
25	11·7	21	9·9	20	8·0	16	6·2	26	15·5	22	13·7
						29	17·3				

The position-angle and distance of Oberon at North Elongation are as follows:—Feb. 1, 14°·9, 45″·3; Apr. 1, 14°·9, 46″·6; June 1, 14°·9, 44″·1.

SATELLITE OF NEPTUNE.



Apparent Orbit of the Satellite of Neptune, as seen in an inverting telescope.

The small circle in the above diagram represents the planet, the arrows show the direction of motion, and the figures indicate the interval from the time of last North-east Elongation.

Greenwich Mean Times of North-East Elongations.

January.		February.		September.		October.		November.		December.	
d	h	d	h	d	h	d	h	d	h	d	h
5	21·4	4	6·8	3	19·9	3	5·0	1	14·1	6	20·3
11	18·5	10	3·8	9	16·9	9	2·0	7	11·1	12	17·3
17	15·6	16	0·9	15	14·0	14	23·0	13	8·1	18	14·4
23	12·6	21	21·9	21	11·0	20	20·1	19	5·2	24	11·4
29	9·7	27	18·9	27	8·0	26	17·1	25	2·2	30	8·4
								30	23·3		

The position-angle and distance of the Satellite when at North-east Elongation are as follows:—January 14, 232°·8, 16″·7; September 18, 235°·0, 16″·7; November 16, 234°·8, 17″·0.

EPHEMERIS FOR PHYSICAL OBSERVATIONS OF THE SUN.

Greenwich Mean Noon.	P.	D.	L.	Greenwich Mean Noon.	P.	D.	L.
1887.	° ′	° ′	° ′	1887.	° ′	° ′	° ′
Jan. 1	+ 1 49	−3 15	62 6	July 5	− 0 44	+3 31	140 14
6	− 0 37	3 50	356 15	10	+ 1 33	4 2	74 4
11	3 2	4 21	290 24	15	3 48	4 31	7 55
16	5 25	4 51	224 34	20	6 1	4 59	301 45
21	7 43	5 19	158 43	25	8 10	5 24	235 36
26	9 56	5 43	92 54	30	10 14	5 47	169 28
31	12 4	6 6	27 4	Aug. 4	12 14	6 8	103 20
Feb. 5	14 5	6 25	321 14	9	14 7	6 26	37 14
10	15 58	6 42	255 24	14	15 55	6 41	331 8
15	17 43	6 55	189 34	19	17 35	6 54	265 3
20	19 19	7 5	123 42	24	19 8	7 4	198 59
25	20 47	7 11	57 51	29	20 33	7 10	132 56
Mar. 2	22 5	7 15	352 0	Sept. 3	21 50	7 14	66 53
7	23 13	7 15	286 7	8	22 59	7 15	0 51
12	24 12	7 11	220 14	13	23 58	7 12	294 50
17	25 0	7 4	154 20	18	24 48	7 7	228 49
22	25 39	6 55	88 24	23	25 29	6 58	162 50
27	26 7	6 42	22 28	28	26 0	6 46	96 51
Apr. 1	26 24	6 26	316 30	Oct. 3	26 20	6 31	30 52
6	26 30	6 7	250 30	8	26 29	6 13	324 54
11	26 25	5 46	184 30	13	26 28	5 52	258 57
16	26 10	5 22	118 30	18	26 15	5 29	193 0
21	25 43	4 56	52 27	23	25 51	5 3	127 4
26	25 5	4 28	346 23	28	25 15	4 35	61 8
May 1	24 16	3 58	280 19	Nov. 2	24 27	4 4	355 11
6	23 16	3 26	214 13	7	23 27	3 32	289 16
11	22 6	2 53	148 6	12	22 16	2 58	223 21
16	20 46	2 19	81 58	17	20 53	2 22	157 26
21	19 15	1 44	15 49	22	19 19	1 46	91 32
26	17 36	1 9	309 40	27	17 34	1 8	25 38
31	15 48	−0 33	243 31	Dec. 2	15 40	+0 30	319 44
June 5	13 52	+0 4	177 20	7	13 37	−0 8	253 51
10	11 51	0 40	111 8	12	11 26	0 47	187 59
15	9 44	1 16	44 58	17	9 9	1 25	122 6
20	7 32	1 51	338 46	22	6 48	2 2	56 15
25	5 17	2 25	272 36	27	4 23	2 39	350 23
30	− 3 1	+2 59	206 34	32	+ 1 56	−3 14	284 31

The position-angle of the Sun's axis, P, is the position-angle of the N. end of the axis from the N. point of the Sun, read in the direction N., E., S., W. In computing D (the heliographic latitude of the centre of the Sun's disk), the inclination of the Sun's axis to the ecliptic has been assumed to be 82° 45′, and the longitude of the ascending node to be 74°. In computing L (the heliographic longitude of the centre of the disk), the Sun's period f rotation has been assumed to be 25·38 days, and the meridian hich passed through the ascending node at the epoch 1854·0 has een taken as the zero meridian.

EPHEMERIS FOR PHYSICAL OBSERVATIONS OF JUPITER, 1887.

Greenwich Mean Times at which the Red Spot passes the Central Meridian.

	d	h		d	h		d	h		d	h		d	h
Jan.	1	7·1	Feb.	8	8·7	Mar.	18	10·0	Apr.	25	11·3	June	2	12·5
	2	12·9		9	14·5		19	5·9		26	17·1		3	8·3
	3	8·8		10	10·3		20	11·7		27	12·9		4	14·1
	4	14·6		11	6·2		21	7·5		28	8·7		5	10·0
	5	10·5		12	12·0		22	13·3		29	14·5		6	15·8
	6	6·3		13	7·8		23	9·1		30	10·4		7	11·6
	7	12·1		14	13·6		24	14·9	May	1	16·2		8	17·4
	8	8·0		15	9·5		25	10·8		2	12·0		9	13·2
	9	13·8		16	15·3		26	16·6		3	7·9		10	9·1
	10	9·6		17	11·1		27	12·4		4	13·7		11	14·9
	11	15·5		18	6·9		28	8·2		5	9·5		12	10·7
	12	11·3		19	12·7		29	14·0		6	15·3		13	16·5
	13	7·2		20	8·6		30	9·9		7	11·1		14	12·3
	14	13·0		21	14·4		31	15·7		8	16·9		15	8·2
	15	8·8		22	10·2	Apr.	1	11·5		9	12·8		16	14·0
	16	14·6		23	6·0		2	7·4		10	8·6		17	9·8
	17	10·5		24	11·8		3	13·2		11	14·4		18	15·6
	18	16·3		25	7·7		4	9·0		12	10·3		19	11·5
	19	12·1		26	13·5		5	14·8		13	16·1		20	17·3
	20	8·0		27	9·3		6	10·6		14	11·9		21	13·1
	21	13·8		28	15·2		7	16·4		15	7·7		22	8·9
	22	9·6	Mar.	1	11·0		8	12·3		16	13·5		23	14·7
	23	15·4		2	6·8		9	8·1		17	9·4		24	10·6
	24	11·3		3	12·6		10	13·9		18	15·2		25	16·4
	25	7·1		4	8·5		11	9·7		19	11·0		26	12·2
	26	12·9		5	14·3		12	15·5		20	16·8		27	8·1
	27	8·8		6	10·1		13	11·4		21	12·6		28	13·9
	28	14·6		7	6·0		14	7·2		22	8·5		29	9·8
	29	10·4		8	11·8		15	13·0		23	14·3		30	15·6
	30	16·2		9	7·6		16	8·9		24	10·1	July	1	11·5
	31	12·0		10	13·4		17	14·7		25	15·9		2	17·3
Feb.	1	7·8		11	9·3		18	10·5		26	11·8		3	13·2
	2	13·6		12	15·1		19	16·3		27	7·6		4	9·0
	3	9·5		13	10·9		20	12·2		28	13·4		5	14·8
	4	15·3		14	6·7		21	8·0		29	9·2		6	10·7
	5	11·1		15	12·5		22	13·8		30	15·0		7	16·5
	6	7·0		16	8·4		23	9·6		31	10·9		8	12·3
	7	12·8		17	14·2		24	15·4	June	1	16·7		9	8·1

Ephemeris for Jupiter (*continued*).

reenwich Mean Times at which the Red Spot passes the Central Meridian (*continued*).

	d	h		d	h		d	h		d	h		d	h
July	10	14·0	July	27	13·0	Aug.	13	12·1	Aug.	30	11·3	Sept.	16	10·3
	11	9·8		28	8·9		14	8·0		31	7·1		17	16·1
	12	15·6		29	14·7		15	13·7	Sept.	1	12·9		18	12·0
	13	11·4		30	10·5		16	9·6		2	8·8		19	7·9
	14	17·2		31	16·3		17	15·4		3	14·6		20	13·7
	15	13·1	Aug.	1	12·2		18	11·3		4	10·4		21	9·5
	16	8·9		2	8·0		19	17·1		5	16·2		22	15·3
	17	14·7		3	13·8		20	12·9		6	12·1		23	11·2
	18	10·6		4	9·7		21	8·8		7	17·9		24	7·0
	19	16·4		5	15·5		22	14·6		8	13·7		25	12·8
	20	12·3		6	11·3		23	10·4		9	9·5		26	8·7
	21	8·1		7	17·1		24	16·2		10	15·3		27	14·5
	22	13·9		8	13·0		25	12·1		11	11·2		28	10·3
	23	9·7		9	8·8		26	7·9		12	7·1		29	16·1
	24	15·5		10	14·6		27	13·7		13	12·9		30	12·0
	25	11·4		11	10·5		28	9·6		14	8·7	Oct.	1	7·9
	26	17·2		12	16·3		29	15·4		15	14·5		2	13·9

obable Dates of Conjunctions of the Red Spot *with the* Equatoreal White Spot *in* 1887 *are*:—January 3, February 16, April 1, May 15, June 29, August 12, and September 25.

STARS WITH REMARKABLE SPECTRA.

The great majority of the stars visible to the naked eye have spectra which ay be grouped under one of two types:—(1) those spectra which are crossed four broad dark ill-defined lines corresponding to hydrogen, and with few no traces of metallic lines; and (2) those in which, as in the solar spectrum, e hydrogen lines are much less conspicuous, and which show a great number narrow lines due to the metals. Amongst the brightest in each class we d:—

Class I.—α, μ Andromedæ; ζ Aquarii; α, δ, ζ, η, θ, λ Aquilæ; β Arietis; η, θ Aurigæ; γ Boötis; α, β, γ, ε, η Canis Majoris; β Canis Minoris; β, δ, assiopeiæ; α Cephei; γ Ceti; α, β, γ Coronæ Borealis; γ, δ Corvi; δ Cygni; ε Delphini; α, ζ Draconis, α, γ, δ, θ, ξ Geminorum; γ, δ, ε, μ Herculis; α, δ, ζ, η Leonis; α, ε, ζ, η Leporis; α, β Libræ; α, γ Lyræ; α, λ, γ Ophiuchi; γ, ζ Pegasi; α, β, γ, δ Persei; α Piscis Australis; α Piscium; β Scorpii; ε, Serpentis; β, η, ξ Tauri; β Trianguli; β, γ, δ, ε, ζ, η Ursæ Majoris; α, γ, ζ, Virginis.

Class II.—β, γ, δ, λ, ο Andromedæ; α, β Aquarii; β, γ, ε Aquilæ; α Arietis; δ, ε, ζ, ι Aurigæ; α, β, δ, ε, η, ρ Boötis; δ Canis Majoris; α^1, α^2 Capricorni; ζ, η Cassiopeiæ; β, γ, ζ, η Cephei; β, ζ, η, θ, ι Ceti; β Corvi; α, β, γ, ε, ζ, τ gni; β Delphini; β, γ, η, θ, ι, ξ, χ Draconis; β Geminorum; β, ζ, η, π rculis; α, ε, ζ Hydræ; γ, ε, μ Leonis; β, γ Leporis; β, ε, κ Ophiuchi; η, μ Pegasi; ε, ζ Persei; η Piscium; δ Scorpii; α Serpentis; α, γ, δ′, ε, ο uri; α Trianguli; α Ursæ Majoris; β Ursæ Minoris; β, ε Virginis.

Procyon and Polaris seem to offer spectra of a type intermediate between the st and second classes.

The principal stars of Orion, with the exception of α Orionis, form a subision of Class I.; the hydrogen lines being still the principal lines of the ectrum, but far fainter and narrower than is usual in stars of the class.

Betelgeuse, α Orionis, appears to present a spectrum intermediate between second and a third class; the third class being those that are crossed by rk shaded bands which terminate for the most part in a very dark sharp edge

STARS WITH REMARKABLE SPECTRA (*continued*).

towards the violet, and gradually shade away towards the red. The brightest stars of this class are as follows:—

CLASS III.—λ, φ, χ Aquarii; π, ρ Arietis; π, υ Aurigæ; υ Boötis; μ Cephei; α, ο, υ Ceti; ν^1, ν^2 Coronæ; ω^3, χ Cygni; λ Draconis; γ, π Eridani; η, μ Geminorum; α Herculis; π, ψ Leonis; δ^2 Lyræ; δ Ophiuchi; o' Orionis; β, φ Pegasi; ρ Persei; δ Piscium; δ Sagittæ; α Scorpii; κ, τ' Serpentis; ρ, μ Ursæ Majoris; δ, ψ, σ Virginis; α Vulpeculæ.

The following stars are also fine examples of the type. The places are given for 1887·0.

Star's Name.	R.A.	Dec.	Star's Name.	R.A.	Dec.
	h m s	° ′		h m s	° ′
R Andromedæ	0 18 4	+37 57·0	DM +47° No. 2291	15 59 16	+47 32·
20 Leporis	5 6 6	−11 59·3	*g* Herculis	16 24 55	+42 7
119 Tauri	5 25 36	+18 30·5	407 Birmingham	17 14 5	+ 2 15·
51 Geminorum	7 6 52	+16 21·1	R Lyræ	18 51 54	+43 47
R Leonis	9 41 29	+11 57·2	569 Birmingham	20 40 18	+17 40·
56 Leonis	10 50 8	+ 6 47·4	3 Aquarii	20 41 47	− 5 26·
40 Comæ Ber.	13 0 52	+23 13·5	LL 42153	21 31 45	+44 52·
R Hydræ	13 23 32	−22 41·7	DM +14° No. 4730	21 59 36	+14 16·
169 Schjellerup	14 19 7	+26 13·1	615 Birmingham	22 34 10	+56 12·
LL 26918	14 40 26	+15 36·4	71 Pegasi	23 27 49	+21 52·
342 Birmingham	14 55 47	+66 23·0	30 Piscium	23 56 10	− 6 38·

R Andromedæ presents some differences from ordinary third type spectra.

The fourth class, which embraces those spectra in which the dark bands have their darkest edge on the side nearer the red, and shade away towards the violet, contains very few stars visible to the naked eye. The following are the most remarkable examples:—

Star's Name.	R.A.	Dec.	Star's Name.	R.A.	Dec.
	h m s	° ′		h m s	° ′
DM +57° No. 702	3 2 45	+57 28·4	DM +68° No. 617	10 37 13	+68 0·9
51 Schjellerup	4 59 31	+ 1 1·3	152 Schjellerup	12 39 49	+46 3·5
72 Schjellerup	6 3 53	+26 2·1	155 *b* Schjellerup	12 51 59	+66 36·3
78 Schjellerup	6 28 46	+38 32·2	229 Schjellerup	19 25 31	+76 20·2
115 Schjellerup	8 49 0	+17 39·7	249 *a* Schjellerup	21 37 16	+34 59·7
132 Schjellerup	10 31 57	−12 47·9	19 Piscium	23 40 37	+ 2 51·6

Besides the above-named four types there are a few stars which show the lines of hydrogen bright in their spectra. Only four bright stars belong to this class—γ Cassiopeiæ, β Lyræ, and γ and η Argûs. The following small stars also have bright lines in their spectra.

Star's Name.	R.A.	Dec.	Star's Name.	R.A.	Dec.
	h m s	° ′		h m s	° ′
LL 13412	6 49 15	−23 46·8	DM +35° No. 4001	20 5 48	+35 49·7
* Argûs	8 51 5	−47 8·4	DM +35° No. 4013	20 7 26	+35 50·8
* Argûs	10 36 59	−58 8·6	DM +37° No. 3821	20 7 48	+38 0·1
Gould 15305	11 5 18	−60 22·0	DM +36° No. 3956	20 10 6	+36 18·0
* Muscæ	13 45 52	−65 57·6	DM +36° No. 3987	20 12 36	+37 3·3
Stone 9168	16 46 15	−41 37·6	P Cygni	20 13 25	+37 39·6
Arg.-Oeltzen 17681	18 1 21	−21 16·2	DM +38° No. 4010	20 15 12	+38 21·3
DM +35° No. 3952	20 1 28	+35 20·2			

MEAN PLACES OF VARIABLE STARS FOR 1887·0.

Star.	R.A.	Dec.	Star.	R.A.	Dec.
	h m s	° ′		h m s	° ′
assiopeiæ ...	0 17 7	+55 10·0	R Boötis	14 32 13	+27 13·6
ndromedæ .	0 18 4	+37 57·1	δ Libræ	14 54 56	− 8 4·2
eti	0 18 19	− 9 57·3	U Coronæ	15 13 35	+32 3·7
ephei	0 52 18	+81 16·0	S Libræ	15 14 55	−19 58·7
iscium	1 11 40	+ 8 20·1	S Serpentis	15 16 22	+14 43·2
culptoris ...	1 21 46	−33 7·7	S Coronæ	15 16 48	+31 46·5
iscium	1 24 48	+ 2 17·9	R Serpentis......	15 45 29	+15 28·7
rietis	1 58 34	+11 59·0	V Coronæ	15 45 29	+39 54·7
rietis.........	2 9 41	+24 31·8	R Herculis	16 1 9	+18 40·6
ti	2 13 38	− 3 29·4	W Scorpii	16 5 10	−19 50·5
ersei	2 14 45	+58 4·2	R Scorpii	16 10 55	−22 39·9
eti	2 20 15	− 0 41·3	S Scorpii	16 10 56	−22 36·6
rietis.........	2 42 1	+17 2·3	W Ophiuchi ...	16 15 20	− 7 25·7
l	3 0 49	+40 31·2	V Ophiuchi ...	16 20 27	−12 9·6
ersei	3 22 51	+35 17·1	U Herculis	16 20 49	+19 8·8
uri	3 54 25	+12 10·3	T Ophiuchi......	16 27 16	−15 53·4
auri	4 22 7	+ 9 54·6	S Ophiuchi......	16 27 45	−16 55·3
uri	4 23 1	+ 9 41·7	W Herculis......	16 31 13	+37 34·3
uri	4 45 29	+17 20·8	R Ursæ Minor .	16 31 30	+72 30·4
rionis	4 52 53	+ 7 57·5	R Draconis......	16 32 22	+66 59·6
eporis	4 54 28	−14 58·6	S Herculis	16 46 45	+15 8·0
urigæ.........	5 19 39	+34 3·0	R Ophiuchi......	17 1 17	−15 56·5
ionis.........	5 23 26	− 4 47·0	U Ophiuchi......	17 10 48	+ 1 20·2
eminorum...	6 8 3	+22 32·3	X (3) Sagittarii.	17 40 27	−27 47·2
onocerotis...	6 19 7	+ 7 8·8	W (γ′) Sagittarii	17 57 49	−29 35·1
eminorum...	6 57 25	+20 44·1	T Herculis	18 4 50	+31 0·1
eminorum..	7 0 33	+22 52·6	T Serpentis......	18 23 18	+ 6 13·5
anis Minor .	7 2 30	+10 12·1	U Sagittarii ...	18 25 14	−19 12·3
eminorum..	7 16 49	+13 18·5	R Scuti	18 41 27	− 5 49·6
onocerotis...	7 25 24	− 9 32·5	β Lyræ	18 45 55	+33 13·9
anis Minor .	7 26 35	+ 8 33·6	R Lyræ	18 51 54	+43 47·8
anis Minor .	7 27 43	+11 59·1	R Aquilæ	19 0 56	+ 8 3·6
anis Minor .	7 35 12	+ 8 38·6	T Sagittarii ...	19 9 43	−17 10·1
eminorum...	7 36 16	+23 42·9	S Sagittarii......	19 12 49	−19 13·7
minorum...	7 42 31	+24 0·9	R Cygni	19 33 47	+49 56·8
ancri.........	8 10 20	+12 4·4	S Vulpeculæ ...	19 43 46	+27 0·3
ancri.........	8 15 17	+17 38·6	χ Cygni	19 46 14	+32 37·7
ancri.........	8 29 18	+19 17·1	η Aquilæ.........	19 46 43	+ 0 43·0
ncri	8 37 29	+19 26·4	S (10) Sagittæ .	19 50 53	+16 20·0
ydræ.........	8 47 40	+ 3 29·7	S Cygni	20 3 8	+57 39·7
ydræ.........	8 50 10	− 8 42·6	R Capricorni ...	20 4 58	−14 36·2
ancri.........	8 50 13	+20 16·9	S Aquilæ.........	20 6 25	+15 17·1
o. Minor. .	9 38 48	+35 1·9	R Sagittæ	20 8 54	+16 23·1
onis.........	9 41 29	+11 57·4	R Delphini......	20 9 28	+ 8 44·8
ydræ	10 31 58	−12 47·8	U Cygni	20 16 6	+47 32·3
sæ Major .	10 36 39	+69 22·1	V Cygni	20 37 40	+47 44·3
ateris	10 55 0	−17 43·1	S Delphini	20 37 53	+16 40·9
onis	11 5 0	+ 6 4·4	T Delphini	20 40 7	+15 59·3
omæ Ber....	11 58 28	+19 24·8	U Capricorni ...	20 41 51	−15 11·9
rginis	12 8 49	− 5 24·4	T Aquarii	20 43 58	− 5 33·9
rvi	12 13 47	−18 37·6	R Vulpeculæ ...	20 59 22	+23 22·4
sæ Major .	12 31 15	+60 6·6	T Cephei.........	21 8 3	+68 1·8
rginis	12 32 46	+ 7 36·6	T Capricorni ...	21 15 47	−15 38·2
sæ Major..	12 39 0	+61 42·7	W Cygni.........	21 31 47	+44 52·2
rginis	12 45 22	+ 6 10·1	S Cephei	21 36 37	+78 6·9
rginis	13 20 12	− 2 47·5	T Pegasi	22 3 23	+11 59·2
rginis	13 21 58	− 2 35·2	δ Cephei	22 24 59	+57 50·2
dræ	13 23 33	−22 41·8	R Lacertæ	22 38 16	+41 46·8
ginis	13 27 6	− 6 36·8	S Aquarii	22 51 3	−20 56·8
ginis	14 4 16	−12 46·1	R Pegasi.........	23 0 59	+ 9 56·0
ötis	14 19 16	+54 19·5	S Pegasi	23 14 50	+ 8 18·1
ötis.........	14 25 13	+39 22·8	R Aquarii	23 37 58	−15 54·6
melop.......	14 26 10	+84 20·7	R Cassiopeiæ ...	23 52 40	+50 45·6

Stars with Remarkable Spectra (*continued*).

towards the violet, and gradually shade away towards the red. The brightest stars of this class are as follows:—

Class III.—λ, φ, χ Aquarii; π, ρ Arietis; π, υ Aurigæ; υ Boötis; μ Cephei; α, ο, υ Ceti; ν^1, ν^2 Coronæ; ω^3, χ Cygni; λ Draconis; γ, π Eridani; η, μ Geminorum; α Herculis; π, ψ Leonis; δ^2 Lyræ; δ Ophiuchi; ο′ Orionis; β, φ Pegasi; ρ Persei; δ Piscium; δ Sagittæ; α Scorpii; κ, τ′ Serpentis; ρ, μ Ursæ Majoris; δ, ψ, σ Virginis; α Vulpeculæ.

The following stars are also fine examples of the type. The places are given for 1887·0.

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	h m s	° ′		h m s	° ′
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20 Leporis	5 6 6	−11 59·3	*g* Herculis	16 24 55	+42 7
119 Tauri	5 25 36	+18 30·5	407 Birmingham ...	17 14 5	+ 2 15
51 Geminorum	7 6 52	+16 21·1	R Lyræ	18 51 54	+43 47
R Leonis	9 41 29	+11 57·2	569 Birmingham ...	20 40 18	+17 40
56 Leonis	10 50 8	+ 6 47·4	3 Aquarii	20 41 47	− 5 26
40 Comæ Ber.	13 0 52	+23 13·5	LL 42153	21 31 45	+44 52
R Hydræ	13 23 32	−22 41·7	DM +14° No. 4730	21 59 36	+14 16
169 Schjellerup......	14 19 7	+26 13·1	615 Birmingham ...	22 34 10	+56 12
LL 26918	14 40 26	+15 36·4	71 Pegasi	23 27 49	+21 52
342 Birmingham ...	14 55 47	+66 23·0	30 Piscium	23 56 10	− 6 38

R Andromedæ presents some differences from ordinary third type spectra.

The fourth class, which embraces those spectra in which the dark bands have their darkest edge on the side nearer the red, and shade away towards the violet, contains very few stars visible to the naked eye. The following are the most remarkable examples:—

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DM +57° No. 702 .	3 2 45	+57 28·4	DM +68° No. 617 .	10 37 13	+68 0·9
51 Schjellerup......	4 59 31	+ 1 1·3	152 Schjellerup......	12 39 49	+46 3·5
72 Schjellerup......	6 3 53	+26 2·1	155 *b* Schjellerup ...	12 51 59	+66 36·3
78 Schjellerup......	6 28 46	+38 32·2	229 Schjellerup......	19 25 31	+76 20·2
115 Schjellerup......	8 49 0	+17 39·7	249 *a* Schjellerup ...	21 37 16	+34 59·7
132 Schjellerup......	10 31 57	−12 47·9	19 Piscium	23 40 37	+ 2 51·6

Besides the above-named four types there are a few stars which show the lines of hydrogen bright in their spectra. Only four bright stars belong to this class—γ Cassiopeiæ, β Lyræ, and γ and η Argûs. The following small stars also have bright lines in their spectra.

Star's Name.	R.A.	Dec.	Star's Name.	R.A.	Dec.
	h m s	° ′		h m s	° ′
LL 13412	6 49 15	−23 46·8	DM +35° No. 4001	20 5 48	+35 49·7
* Argûs	8 51 5	−47 8·4	DM +35° No. 4013	20 7 26	+35 50·8
* Argûs	10 36 59	−58 8·6	DM +37° No. 3821	20 7 48	+38 0·1
Gould 15305.........	11 5 18	−60 22·0	DM +36° No. 3956	20 10 6	+36 18·0
* Muscæ...............	13 45 52	−65 57·6	DM +36° No. 3987	20 12 36	+37 3·3
Stone 9168	16 46 15	−41 37·6	P Cygni	20 13 25	+37 39·6
Arg.-Oeltzen 17681 .	18 1 21	−21 16·2	DM +38° No. 4010	20 15 12	+38 21·3
DM +35° No. 3952	20 1 28	+35 20·2			

MEAN PLACES OF VARIABLE STARS FOR 1887·0.

Star.	R.A.	Dec.	Star.	R.A.	Dec.
	h m s	° ′		h m s	° ′
siopeiæ ...	0 17 7	+55 10·0	R Boötis.........	14 32 13	+27 13·6
dromedæ .	0 18 4	+37 57·1	δ Libræ	14 54 56	− 8 4·2
i	0 18 19	− 9 57·3	U Coronæ	15 13 35	+32 3·7
phei	0 52 18	+81 16·0	S Libræ	15 14 55	−19 58·7
cium	1 11 40	+ 8 20·1	S Serpentis......	15 16 22	+14 43·2
lptoris ...	1 21 46	−33 7·7	S Coronæ	15 16 48	+31 46·5
cium	1 24 48	+ 2 17·9	R Serpentis......	15 45 29	+15 28·7
etis	1 58 34	+11 59·0	V Coronæ	15 45 29	+39 54·7
ietis.........	2 9 41	+24 31·8	R Herculis......	16 1 9	+18 40·6
i	2 13 38	− 3 29·4	W Scorpii	16 5 10	−19 50·5
sei	2 14 45	+58 4·2	R Scorpii	16 10 55	−22 39·9
i............	2 20 15	− 0 41·3	S Scorpii.........	16 10 56	−22 36·6
etis.........	2 42 1	+17 2·3	W Ophiuchi ...	16 15 20	− 7 25·7
....	3 0 49	+40 31·2	V Ophiuchi ...	16 20 27	−12 9·6
rsei	3 22 51	+35 17·1	U Herculis......	16 20 49	+19 8·8
ri	3 54 25	+12 10·3	T Ophiuchi......	16 27 16	−15 53·4
ri	4 22 7	+ 9 54·6	S Ophiuchi......	16 27 45	−16 55·3
ri	4 23 1	+ 9 41·7	W Herculis......	16 31 13	+37 34·3
ri	4 45 29	+17 20·8	R Ursæ Minor .	16 31 30	+72 30·4
onis	4 52 53	+ 7 57·5	R Draconis......	16 32 22	+66 59·6
oris	4 54 28	−14 58·6	S Herculis	16 46 45	+15 8·0
igæ.........	5 19 39	+34 3·0	R Ophiuchi......	17 1 17	−15 56·5
onis.........	5 23 26	− 4 47·0	U Ophiuchi......	17 10 48	+ 1 20·2
inorum...	6 8 3	+22 32·3	X (3) Sagittarii.	17 40 27	−27 47·2
ocerotis...	6 19 7	+ 7 8·8	W (γ′) Sagittarii	17 57 49	−29 35·1
inorum...	6 57 25	+20 44·1	T Herculis	18 4 50	+31 0·1
inorum..	7 0 33	+22 52·6	T Serpentis......	18 23 18	+ 6 13·5
is Minor .	7 2 30	+10 12·1	U Sagittarii ...	18 25 14	−19 12·3
inorum..	7 16 49	+13 18·5	R Scuti	18 41 27	− 5 49·6
ocerotis...	7 25 24	− 9 32·5	β Lyræ	18 45 55	+33 13·9
is Minor .	7 26 35	+ 8 33·6	R Lyræ	18 51 54	+43 47·8
is Minor .	7 27 43	+11 59·1	R Aquilæ	19 0 56	+ 8 3·6
is Minor .	7 35 12	+ 8 38·6	T Sagittarii ...	19 9 43	−17 10·1
inorum...	7 36 16	+23 42·9	S Sagittarii......	19 12 49	−19 13·7
inorum...	7 42 31	+24 0·9	R Cygni	19 33 47	+49 56·8
cri.........	8 10 20	+12 4·4	S Vulpeculæ ...	19 43 46	+27 0·3
cri.........	8 15 17	+17 38·6	χ Cygni	19 46 14	+32 37·7
cri.........	8 29 18	+19 17·1	η Aquilæ.........	19 46 43	+ 0 43·0
cri	8 37 29	+19 26·4	S (10) Sagittæ .	19 50 53	+16 20·0
dræ.........	8 47 40	+ 3 29·7	S Cygni	20 3 8	+57 39·7
dræ.........	8 50 10	− 8 42·6	R Capricorni ...	20 4 58	−14 36·2
cri.........	8 50 13	+20 16·9	S Aquilæ.........	20 6 25	+15 17·1
. Minor. .	9 38 48	+35 1·9	R Sagittæ	20 8 54	+16 23·1
nis.........	9 41 29	+11 57·4	R Delphini......	20 9 28	+ 8 44·8
dræ	10 31 58	−12 47·8	U Cygni	20 16 6	+47 32·3
æ Major .	10 36 39	+69 22·1	V Cygni	20 37 40	+47 44·3
teris	10 55 0	−17 43·1	S Delphini	20 37 53	+16 40·9
nis	11 5 0	+ 6 4·4	T Delphini	20 40 7	+15 59·3
næ Ber....	11 58 28	+19 24·8	U Capricorni ...	20 41 51	−15 11·9
inis	12 8 49	− 5 24·4	T Aquarii	20 43 58	− 5 33·9
vi	12 13 47	−18 37·6	R Vulpeculæ ...	20 59 22	+23 22·4
e Major .	12 31 15	+60 6·6	T Cephei.........	21 8 3	+68 1·8
ginis	12 32 46	+ 7 36·6	T Capricorni ...	21 15 47	−15 38·2
e Major..	12 39 0	+61 42·7	W Cygni.........	21 31 47	+44 52·2
ginis	12 45 22	+ 6 10·1	S Cephei	21 36 37	+78 6·9
ginis	13 20 12	− 2 47·5	T Pegasi	22 3 23	+11 59·2
inis	13 21 58	− 2 35·2	δ Cephei	22 24 59	+57 50·2
dræ	13 23 33	−22 41·8	R Lacertæ	22 38 16	+41 46·8
inis	13 27 6	− 6 36·8	S Aquarii	22 51 3	−20 56·8
inis	14 4 16	−12 46·1	R Pegasi.........	23 0 59	+ 9 56·0
is	14 19 16	+54 19·5	S Pegasi	23 14 50	+ 8 18·1
tis.........	14 25 13	+39 22·8	R Aquarii	23 37 58	−15 54·6
elop.......	*14 26 10*	*+84 20·7*	R Cassiopeiæ ...	23 52 40	+50 45·6

MINIMA OF VARIABLE STARS OF THE ALGOL TYPE.

U CEPHEI.

	d	h	m
January.	1	12	3
	3	23	53
	6	11	43
	8	23	33
	11	11	22
	13	23	12
	16	11	2
	18	22	51
	21	10	41
	23	22	31
	26	10	21
	28	22	10
	31	10	0
February.	2	21	50
	5	9	39
	7	21	29
	10	9	19
	12	21	9
	15	8	58
	17	20	48
	20	8	38
	22	20	28
	25	8	17
	27	20	7
March.	2	7	57
	4	19	46
	7	7	36
	9	19	26
	12	7	16
	14	19	5
	17	6	55
	19	18	45
	22	6	35
	24	18	24
	27	6	14
	29	18	4
April.	1	5	53
	3	17	43
	6	5	33
	8	17	23
	11	5	12
	13	17	2
	16	4	52
	18	16	42
	21	4	31
	23	16	21
	26	4	11
	28	16	0

U CEPHEI.

	d	h	m
May.	1	3	50
	3	15	40
	6	3	30
	8	15	19
	11	3	9
	13	14	59
	16	2	48
	18	14	38
	21	2	28
	23	14	18
	26	2	7
	28	13	57
	31	1	47
June.	2	13	37
	5	1	26
	7	13	16
	10	1	6
	12	12	55
	15	0	45
	17	12	35
	20	0	25
	22	12	14
	25	0	4
	27	11	54
	29	23	44
July.	2	11	33
	4	23	23
	7	11	13
	9	23	2
	12	10	52
	14	22	42
	17	10	32
	19	22	21
	22	10	11
	24	22	1
	27	9	51
	29	21	40
August.	1	9	30
	3	21	20
	6	9	9
	8	20	59
	11	8	49
	13	20	39
	16	8	28
	18	20	18
	21	8	8
	23	19	57
	26	7	47
	28	19	37
	31	7	27

U CEPHEI.

	d	h	m
September.	2	19	16
	5	7	6
	7	18	56
	10	6	46
	12	18	35
	15	6	25
	17	18	15
	20	6	4
	22	17	54
	25	5	44
	27	17	34
	30	5	23
October.	2	17	13
	5	5	3
	7	16	53
	10	4	42
	12	16	32
	15	4	22
	17	16	11
	20	4	1
	22	15	51
	25	3	41
	27	15	30
	30	3	20
November.	1	15	10
	4	3	0
	6	14	49
	9	2	39
	11	14	29
	14	2	18
	16	14	8
	19	1	59
	21	13	48
	24	1	38
	26	13	27
	29	1	17
December.	1	13	6
	4	0	56
	6	12	46
	9	0	36
	11	12	25
	14	0	15
	16	12	5
	18	23	55
	21	11	44
	23	23	34
	26	11	24
	28	23	13
	31	11	3

ALGOL.

	d	h	m
January.	1	6	36
	4	3	25
	7	0	14
	9	21	3
	12	17	52
	15	14	41
	18	11	29
	21	8	18
	24	5	7
	27	1	56
	29	22	45
February.	1	19	34
	4	16	23
	7	13	12
	10	10	1
	13	6	50
	16	3	38
	19	0	27
	21	21	16
	24	18	5
	27	14	54
March.	2	11	43
	5	8	32
	8	5	21
	11	2	10
	13	22	58
	16	19	47
	19	16	36
	22	13	25
	25	10	14
	28	7	3
	31	3	52
April.	3	0	41
	5	21	30
	8	18	19
	11	15	7
	14	11	56
	17	8	45
	20	5	34
	23	2	23
	25	23	12
	28	20	1
July.	3	18	45
	6	15	34
	9	12	23
	12	9	12
	15	6	1

ALGOL.

	d	h	m
July.	18	2	50
	20	23	39
	23	20	28
	26	17	17
	29	14	5
August.	1	10	54
	4	7	43
	7	4	32
	10	1	21
	12	22	10
	15	18	59
	18	15	48
	21	12	37
	24	9	25
	27	6	14
	30	3	3
September.	1	23	52
	4	20	41
	7	17	30
	10	14	19
	13	11	8
	16	7	57
	19	4	45
	22	1	34
	24	22	23
	27	19	12
	30	16	1
October.	3	12	50
	6	9	39
	9	6	28
	12	3	17
	15	0	5
	17	20	54
	20	17	43
	23	14	32
	26	11	21
	29	8	10
November.	1	4	59
	4	1	48
	6	22	37
	9	19	26
	12	16	14
	15	13	3
	18	9	52
	21	6	41
	24	3	30
	27	0	19
	29	21	8

Minima of Variable Stars of the Algol Type (continued).

m
57
46
35
23
12
1
50
39
28
17
6

RI.

m
12
4
56
48
41
33
25
18
10
2
55
47
39
31
24
16
8
1
23
16
8
0
53
45
37
30
22
14
6
59
51
43
36
28

λ Tauri.

	d	h	m
October.	4	8	20
	8	7	13
	12	6	5
	16	4	57
	20	3	49
	24	2	42
	28	1	34
November.	1	0	26
	4	23	19
	8	22	11
	12	21	3
	16	19	56
	20	18	48
	24	17	40
	28	16	32
December.	2	15	25
	6	14	17
	10	13	9
	14	12	2
	18	10	54
	22	9	46
	26	8	39
	30	7	31

S Cancri.

	d	h	m
Jan.	4	13	40
	14	1	18
	23	12	55
Feb.	2	0	33
	11	12	11
	20	23	49
Mar.	2	11	26
	11	23	4
	21	10	42
	30	22	20
April.	9	9	57
	18	21	35
	28	9	13
May.	7	20	51
	17	8	28
	26	20	6

S Cancri.

	d	h	m
June.	5	7	44
	14	19	22
	24	6	59
Sept.	8	4	1
	17	15	39
	27	3	17
Oct.	6	14	55
	16	2	32
	25	14	10
Nov.	4	1	48
	13	13	26
	23	1	3
Dec.	2	12	41
	12	0	19
	21	11	57
	30	23	34

δ Libræ.

	d	h	m
January.	3	7	41
	5	15	33
	7	23	24
	10	7	15
	12	15	7
	14	22	58
	17	6	49
	19	14	41
	21	22	32
	24	6	23
	26	14	15
	28	22	6
	31	5	57
February.	2	13	49
	4	21	40
	7	5	31
	9	13	23
	11	21	14
	14	5	5
	16	12	57
	18	20	48
	21	4	39
	23	12	31
	25	20	22
	28	4	13

δ Libræ.

	d	h	m
March.	2	12	5
	4	19	56
	7	3	47
	9	11	39
	11	19	30
	14	3	21
	16	11	13
	18	19	4
	21	2	55
	23	10	47
	25	18	38
	28	2	29
	30	10	21
April.	1	18	12
	4	2	3
	6	9	55
	8	17	46
	11	1	37
	13	9	29
	15	17	20
	18	1	11
	20	9	3
	22	16	54
	25	0	45
	27	8	37
	29	16	28
May.	2	0	19
	4	8	11
	6	16	2
	8	23	53
	11	7	45
	13	15	36
	15	23	27
	18	7	19
	20	15	10
	22	23	1
	25	6	53
	27	14	44
	29	22	35
June.	1	6	27
	3	14	18
	5	22	9
	8	6	1
	10	13	52
	12	21	43
	15	5	35
	17	13	26
	19	21	17
	22	5	9
	24	13	0
	26	0	51
	29	4	43

δ Libræ.

	d	h	m
July.	1	12	34
	3	20	25
	6	4	17
	8	12	8
	10	19	59
	13	3	51
	15	11	42
	17	19	33
	20	3	25
	22	11	16
	24	19	7
	27	2	59
	29	10	50
	31	18	41
August.	3	2	33
	5	10	24
	7	18	15
	10	2	7
	12	9	58
	14	17	49
	17	1	41
	19	9	32
	21	17	23
	24	1	15
	26	9	6
	28	16	57
	31	0	49
September.	2	8	40
	4	16	31
	7	0	23
	9	8	14
	11	16	5
	13	23	57
	16	7	48
	18	15	39
	20	23	31
	23	7	22
	25	15	13
	27	23	5
	30	6	56
Oct.	2	14	47
	4	22	38
	7	6	30
December.	16	2	10
	18	10	2
	20	17	53
	23	1	44
	25	9	36
	27	17	27
	30	1	18

Minima of Variable Stars of the Algol Type (continued).

U CORONÆ.	d	h	m
January.	3	3	22
	6	14	14
	10	1	5
	13	11	56
	16	22	47
	20	9	39
	23	20	30
	27	7	21
	30	18	12
February.	3	5	3
	6	15	55
	10	2	46
	13	13	37
	17	0	28
	20	11	19
	23	22	11
	27	9	2
March.	2	19	53
	6	6	45
	9	17	36
	13	4	27
	16	15	18
	20	2	10
	23	13	1
	26	23	52
	30	10	43
April.	2	21	35
	6	8	26
	9	19	17
	13	6	8
	16	17	0
	20	3	51
	23	14	42
	27	1	33
	30	12	25
May.	3	23	16
	7	10	7
	10	20	58
	14	7	50
	17	18	41
	21	5	32
	24	16	23
	28	3	15
	31	14	6
June.	4	0	57
	7	11	48
	10	22	39
	14	9	31
	17	20	22

U CORONÆ.	d	h	m
June.	21	7	13
	24	18	4
	28	4	56
July.	1	15	47
	5	2	38
	8	13	29
	12	0	21
	15	11	12
	18	22	3
	22	8	54
	25	19	46
	29	6	37
August.	1	17	28
	5	4	19
	8	15	11
	12	2	2
	15	12	53
	18	23	44
	22	10	36
	25	21	27
	29	8	18
September.	1	19	9
	5	6	1
	8	16	52
	12	3	43
	15	14	34
	19	1	26
	22	12	17
	25	23	8
	29	9	59
October.	2	20	51
	6	7	42
	9	18	33
	13	5	24
	16	16	15
	20	3	7
	23	13	58
	27	0	49
	30	11	40
December.	4	0	13
	7	11	4
	10	21	55
	14	8	47
	17	19	38
	21	6	29
	24	17	20
	28	4	12
	31	15	3

U OPHIUCHI.	d	h	m
January.	1	3	55
	3	16	18
	6	4	41
	8	17	4
	11	5	27
	13	17	50
	16	6	13
	18	18	36
	21	6	59
	23	19	22
	26	7	45
	28	20	8
	31	8	31
February.	2	20	54
	5	9	17
	7	21	40
	10	10	3
	12	22	26
	15	10	49
	17	23	12
	20	11	35
	22	23	58
	25	12	21
	28	0	44
March.	2	13	8
	5	1	31
	7	13	54
	10	2	17
	12	14	40
	15	3	3
	17	15	26
	20	3	49
	22	16	12
	25	4	35
	27	16	58
	30	5	21
April.	1	17	44
	4	6	7
	6	18	30
	9	6	53
	11	19	16
	14	7	39
	16	20	2
	19	8	25
	21	20	48
	24	9	11
	26	21	34
	29	9	57

U OPHIUCHI.	d	h	m
May.	1	22	21
	4	10	44
	6	23	7
	9	11	30
	11	23	53
	14	12	16
	17	0	39
	19	13	2
	22	1	25
	24	13	48
	27	2	11
	29	14	34
June.	1	2	57
	3	15	20
	6	3	43
	8	16	6
	11	4	29
	13	16	52
	16	5	15
	18	17	38
	21	6	1
	23	18	24
	26	6	47
	28	19	10
July.	1	7	33
	3	19	56
	6	8	20
	8	20	43
	11	9	6
	13	21	29
	16	9	52
	18	22	15
	21	10	38
	23	23	1
	26	11	24
	28	23	47
	31	12	10
August.	3	0	33
	5	12	56
	8	1	20
	10	13	42
	13	2	6
	15	14	28
	18	2	52
	20	15	14
	23	3	38
	25	16	0
	28	4	24
	30	16	46

U OPHIUCHI.	d	h	m
September.	2	5	10
	4	17	32
	7	5	56
	9	18	19
	12	6	42
	14	19	5
	17	7	28
	19	19	51
	22	8	14
	24	20	37
	27	9	0
	29	21	23
October.	2	9	46
	4	22	9
	7	10	32
	9	22	55
	12	11	19
	14	23	42
	17	12	5
	20	0	28
	22	12	51
	25	1	14
	27	13	37
	30	2	0
November.	1	14	23
	4	2	46
	6	15	9
	9	3	32
	11	15	55
	14	4	18
	16	16	41
	19	5	4
	21	17	27
	24	5	50
	26	18	13
	29	6	36

Note.

For U Ophiuchi, the period of which is 20ʰ 8ᵐ, only every third minimum is given.

VARIABLES OF SHORT PERIOD NOT OF THE ALGOL TYPE.

Note.—The times of minima only are given; the times of maxima may be found by adding the interval printed under the name of the star.

T MONOCEROTIS.
(8ᵈ 0ʰ.)

	d	h		d	h
Jan.	1	0	Aug.	4	21
	28	0		31	21
Feb.	23	23	Sept.	27	20
Mar.	22	23	Oct.	24	20
Apr.	18	22	Nov.	20	19
May	15	22	Dec.	17	19

ζ GEMINORUM.
(5ᵈ 0ʰ.)

	d	h		d	h
Jan.	8	5	Aug.	29	18
	18	9	Sept.	8	22
	28	12		19	1
Feb.	7	16		29	5
	17	20	Oct.	9	9
	27	23		19	12
Mar.	10	3		29	16
	20	7	Nov.	8	20
	30	10		18	23
Apr.	9	14		29	3
	19	18	Dec.	9	7
	29	21		19	10
May	10	1		29	14

W VIRGINIS.
(8ᵈ 5ʰ.)

	d	h		d	h
Jan.	10	17	May	28	21
	27	23	June	15	3
Feb.	14	6	July	2	10
Mar.	3	12		19	17
	20	19	Aug.	6	0
Apr.	7	1		23	6
	24	8	Dec.	4	22
May	11	14		22	4

X (3) SAGITTARII.
(2ᵈ 21ʰ.)

	d	h		d	h
Mar.	2	2	May	4	4
	9	2		11	5
	16	2		18	5
	23	3		25	5
	30	3	June	1	6
Apr.	6	3			6
	13	3		15	6
	20	4		22	7
	27	4		29	7

X (3) SAGITTARII (*continued*).

	d	h		d	h
July	6	7	Aug.	31	10
	13	8	Sept.	7	10
	20	8		14	11
	27	8		21	11
Aug.	3	9		28	11
	10	9	Oct.	5	12
	17	9		12	12
	24	10		19	12

W (γ′) SAGITTARII.
(3ᵈ 4ʰ.)

	d	h		d	h
Feb.	23	2	June	24	14
Mar.	2	16	July	2	4
	10	6		9	19
	17	21		17	9
	25	11		24	23
Apr.	2	1	Aug.	1	13
	9	15		9	4
	17	6		16	18
	24	20		24	8
May	2	10		31	22
	10	0	Sept.	8	12
	17	15		16	3
	25	5		23	17
June	1	19	Oct.	1	7
	9	9		8	21
	16	23		16	12

U SAGITTARII.
(2ᵈ 23ʰ.)

	d	h		d	h
Mar.	1	21	June	4	8
	8	15		11	1
	15	9		17	19
	22	3		24	13
	28	21	July	1	7
Apr.	4	15		8	1
	11	9		14	19
	18	2		21	13
	24	20		28	7
May	1	14	Aug.	4	1
	8	8		10	19
	15	2		17	13
	21	20		24	7
	28	14		31	0

U SAGITTARII (*continued*).

	d	h		d	h
Sept.	6	18	Oct.	10	12
	13	12		17	6
	20	6		24	0
	27	0		30	18
Oct.	3	18	Nov.	6	12

β LYRÆ.
(Max. 3ᵈ 5ʰ.
Secondary Min. 6ᵈ 11ʰ.
Max. 9ᵈ 16ʰ.)

	d	h		d	h
Jan.	3	0	July	2	18
	15	22		15	16
	28	20		28	14
Feb.	10	18	Aug.	10	11
	23	16		23	9
Mar.	8	13	Sept.	5	7
	21	11		18	5
Apr.	3	9	Oct.	1	3
	16	7		14	1
	29	5		26	23
May	12	3	Nov.	8	20
	25	0		21	18
June	6	22	Dec.	4	16
	19	20		17	14

η AQUILÆ.
(2ᵈ 9ʰ.)

	d	h		d	h
Mar.	8	17	July	23	1
	15	21		30	5
	23	1	Aug.	6	9
	30	5		13	14
Apr.	6	10		20	18
	13	14		27	22
	20	18	Sept.	4	3
	27	22		11	7
May	5	3		18	11
	12	7		25	15
	19	11	Oct.	2	19
	26	15		10	0
June	2	19		17	4
	10	0		24	8
	17	4		31	12
	24	8	Nov.	7	17
July	1	12		14	21
	8	16		22	1
	15	21		29	5

VARIABLES OF SHORT PERIOD (*continued*).

S (10) SAGITTÆ.
(3d 0h.)

	d	h		d	h
Mar.	7	12	July	28	0
	15	21	Aug.	5	9
	24	6		13	18
Apr.	1	16		22	3
	10	1		30	12
	18	10	Sept.	7	21
	26	19		16	6
May	5	4		24	15
	13	13	Oct.	3	1
	21	22		11	10
	30	8		19	19
June	7	17		28	4
	16	2	Nov.	5	13
	24	11		13	22
July	2	20		22	7
	11	5		30	17
	19	14	Dec.	9	2

δ CEPHEI.
(1d 15h.)

	d	h		d	h		d	h		d	h
Jan.	6	2	Apr.	7	8	July	7	13	Oct.	6	19
	11	11		12	16		12	22		12	4
	16	20		18	1		18	7		17	13
	22	5		23	10		23	16		22	22
	27	13		28	19		29	1		28	7
Feb.	1	22	May	4	4	Aug.	3	10	Nov.	2	15
	7	7		9	12		8	18		8	0
	12	16		14	21		14	3		13	9
	18	0		20	6		19	12		18	18
	23	9		25	15		24	21		24	3
	28	18		31	0		30	6		29	12
Mar.	6	3	June	5	9	Sept.	4	14	Dec.	4	20
	11	12		10	17		9	23		10	5
	16	20		16	2		15	8		15	14
	22	5		21	11		20	17		20	23
	27	14		26	20		26	2		26	8
Apr.	1	23	July	2	5	Oct.	1	11		31	16

BINARY STARS.

The following are amongst the best known and most remarkable.

No.	Name of Star.	R.A. 1880.	Dec. 1880.	Mag.	Position.	Distance.	Epoch. 1800+.
		h m	° ′		°	″	
1.	η Cassiopeiæ	0 41·8	+57 11	4; 8	165·7	5·16	82·87
2.	36 Andromedæ	0 48·3	+22 58	6; 7	2·0	1·35	85·28
3.	*p* Eridani	1 35·2	−56 49	6; 6	230·5	7·10	85·19
4.	ι Cassiopeiæ AB	2 19·2	+66 51	4; 7	82·0	2·23	83·67
5.	„ AC	„	„	4; 8	110·0	7·43	83·52
6.	γ Ceti.....................	2 37·1	+ 2 44	3; 7	286·0	3·04	77·99
7.	98 Eridani................	3 30·6	+ 0 12	6; 8	241·9	6·47	80·02
8.	40 „ AB	4 9·8	− 7 49	4; 9	105·6	81·90	79·18
9.	2 Camelopardalis	4 30·4	+53 15	5; 7	291·9	1·87	82·93
10.	*i* Orionis OΣ 98	5 1·3	+ 8 20	6; 7	203·3	1·15	82·76
11.	118 Tauri	5 21·9	+25 3	6; 7	198·2	5·04	76·16
12.	12 Lyncis AB	6 35·6	+59 34	5; 6	128·4	1·70	82·76
13.	„ AC	„	„	5; 7	126·7	8·29	82·20
14.	Sirius......................	6 39·9	−16 32	1; 9	30·6	7·39	86·22
15.	38 Geminorum	6 47·3	+13 20	5; 8	163·4	6·19	82·89
16.	Castor AB...............	7 27·0	+32 9	2; 3	232·2	5·74	85·15

BINARY STARS (*continued*).

ame of Star.	R.A. 1880.	Dec. 1880.	Mag.	Position.	Distance.	Epoch 1800+.	Observer.
	h m	° ′		°	″		
ncri AB	8 5·3	+18 1	6; 7	59·4	1·05	85·29	E.
$\frac{A+BC}{2}\Big\}$	"	"	6; 7	126·8	5·44	85·29	E.
dræ	8 40·4	+ 6 52	4; 8	226·0	3·43	82·89	E.
sæ Majoris	8 51·0	+48 31	4; 12	356·7	9·56	83·40	E.
rsæ Majoris	8 59·8	+67 37	5; 8	238·7	2·65	82·86	E.
onis	9 22·0	+ 9 35	6; 7	90·6	0·72	85·27	E.
onis AB	10 13·4	+20 27	2; 4	113·0	3·45	85·12	E.
sæ Majoris	11 11·8	+32 13	4; 5	245·2	2·12	85·36	E.
nis	11 17·6	+11 12	4; 8	64·6	2·76	83·07	E.
ntauri	12 34·9	−48 18	4; 4	1·3	1·39	80·46	R.
rginis	12 35·6	− 0 47	3; 3	336·1	5·32	84·89	E.
omæ Berenices	12 47·4	+21 54	5; 8	65·4	1·16	85·34	P.
omæ Berenices	13 4·2	+18 10	6; 6	192·1	0·56	82·93	E.
57	13 28·2	+ 0 18	8; 9	69·4	2·31	82·47	S.
anum Venat.	13 32·2	+36 55	6; 7	329·1	0·89	85·37	P.
rginis	13 37·0	+ 4 9	6; 8	230·1	3·45	79·41	H.
19	14 9·3	+ 3 42	8; 8	11·5	1·39	85·41	P.
ntauri	14 31·8	−60 20	1; 2	200·8	14·05	85·57	T.
ötis	14 39·7	+27 35	3; 6	328·0	2·88	85·41	P.
ötis	14 45·8	+19 36	5; 7	263·1	3·61	85·55	E.
Boötis	14 59·8	+48 7	5; 6	240·9	5·02	83·35	E.
oronæ Bor.	15 18·3	+30 43	5; 6	170·0	0·61	85·58	E.
Boötis	15 20·0	+37 46	7; 8	116·9	0·85	85·63	E.
rpentis	15 29·1	+10 56	3; 5	188·8	3·34	85·53	B.
298	15 31·7	+40 13	7; 8	60·9	0·27	85·65	E.
1) Scorpii	15 57·8	−11 2	5; 5	6·9	1·12	78·03	H.
oronæ Bor.	16 10·2	+34 10	9; 9	207·3	4·09	85·74	E.
ares	16 22·0	−26 10	1; 8	271·5	3·25	77·56	H.
phiuchi	16 24·9	+ 2 15	4; 6	42·6	1·64	85·63	E.
erculis	16 36·8	+31 49	3; 7	98·0	1·82	85·71	E.
107	16 47·1	+28 52	7; 9	236·1	0·78	85·57	E.
120	17 0·0	+28 15	6; 9	249·6	5·61	85·49	P.
Ophiuchi AB	17 8·0	−26 25	5; 7	230·1	4·51	77·00	H.
erculis	17 19·5	+37 15	4; 5	310·0	3·92	79·47	H.
173	17 24·2	− 0 58	6; 6	21·9	0·30	85·66	E.
phiuchi	17 56·5	− 8 11	5; 6	251·3	1·76	85·57	B.
Ophiuchi	17 59·4	+ 2 33	4; 6	24·3	2·07	85·64	E.
yræ	18 40·4	+39 33	5; 6	14·4	3·00	85·49	B.
yræ	18 40·4	+39 29	5; 5	134·6	2·34	85·49	B.
oronæ Australis	18 58·3	−37 14	6; 6	37·8	1·62	83·62	W.
gni	19 41·2	+44 50	3; 8	319·0	1·84	85·90	E.
elphini	20 41·4	+15 42	4; 5	271·2	11·06	85·55	B.
29	20 45·1	− 6 4	6; 7	155·9	0·40	79·76	H.
uulei AB	20 53·1	+ 3 50	6; 6	286·4	1·26	84·54	E.
ygni	21 1·4	+38 7	5; 6	117·7	19·98	79·71	H.
gni	21 38·9	+28 12	4; 5	119·5	3·18	85·67	B.
phei	22 0·3	+64 2	5; 6	284·0	6·53	85·69	B.
uarii	22 22·6	− 0 38	4; 4	326·8	3·18	75·77	B.
phei	23 13·7	+67 27	5; 8	191·3	2·83	83·36	E.

lumn headed "Observer," B. denotes Dr. L. de Ball; E., Dr. R. Engelmann; H., Prof. ; P., Mons. J. Perrotin; R., Mr. H. C. Russell; S., Prof. Schiaparelli; T., Mr. Teb- Mr. H. C. Wilson.

SELENOGRAPHICAL LONGITUDES AND LATITUDES OF LUNAR CRATERS.

Name of Crater.	Longitude. +=West. −=East.	Latitude. +=North. −=South.	Name of Crater.	Longitude. +=West. −=East.	Latitude. +=North. −=South.
	° ′	° ′		° ′	° ′
Schubert A	+77 16	+ 2 28	Alphonsus A ...	− 3 14	−12 59
Hansen A	+74 0	+13 17	Mösting	− 5 35	− 0 36
Langrenus	+60 34	− 8 22	Moretus	− 7 9	−69 45
Petavius	+59 16	−24 39	Archimedes A...	− 7 11	+27 45
Cleomedes A ...	+54 17	+28 24	Hell	− 8 20	−31 59
Picard	+53 52	+14 28	Lalande	− 8 47	− 4 25
Thales	+49 12	+61 58	Pico	− 9 13	+45 23
Messier	+47 9	− 1 59	Eratosthenes ...	−11 34	+14 25
Proclus	+46 30	+16 10	Tycho	−11 52	−42 52
Taruntius	+45 58	+ 5 40	Timocharis	−13 0	+26 43
Cepheus A	+45 40	+40 59	Clavius C.........	−14 40	−57 17
Goclenius	+44 27	− 9 59	Hesiodus B......	−17 0	−26 50
Fabricius	+40 46	−42 8	Copernicus	−19 56	+ 9 21
Hercules	+38 23	+46 23	Pytheas	−20 34	+20 14
Capella	+34 48	− 7 33	Bullialdus	−22 6	−20 26
Democritus......	+33 30	+62 8	Reinhold	−22 37	+ 3 13
Censorinus	+32 27	− 0 24	Carlini.........	−24 1	+33 23
Piccolomini ...	+31 35	−29 11	La Hire	−25 10	+27 18
Vitruvius.........	+31 2	+17 36	Laplace A	−26 34	+43 16
Maskelyne	+29 35	+ 2 32	Scheiner A	−26 36	−59 58
Mutus	+29 22	−63 6	Campanus	−27 27	−27 37
Mädler	+29 12	−10 56	Mayer	−28 50	+15 33
Posidonius A ...	+29 7	+31 36	Euler	−28 57	+22 57
LeMonnier A ...	+29 4	+26 0	Euclides	−29 16	− 7 10
Burg	+27 32	+44 57	Milichius.........	−29 40	+10 0
Theophilus	+26 18	−11 21	Landsberg A ...	−31 5	+ 0 2
Lindenau	+24 30	−31 52	Ramsden	−31 42	−32 26
Aristoteles C ...	+23 34	+57 26	Heraclides	−34 1	+41 8
Plinius	+23 23	+15 17	Delisle...........	−34 48	+29 59
Bessel	+17 22	+21 54	Brayley	−36 25	+20 54
Delambre	+17 15	− 1 47	Encke	−36 36	+ 4 18
Dionysius	+17 9	+ 2 51	Bessarion E......	−37 1	+14 59
Sacrobosco	+15 41	−23 42	Vitello............	−37 8	−30 0
Menelaus........	+15 31	+16 24	Kepler............	−37 41	+ 7 57
Dollond	+14 12	−10 15	Wichmann	−37 56	− 7 41
Linné	+11 32	+27 47	Gassendi	−39 31	−16 58
Agrippa	+10 18	+ 4 2	Flamsteed	−44 12	− 4 31
Manilius	+ 8 47	+14 27	Wollaston	−46 54	+30 17
Hipparchus C...	+ 8 4	− 7 23	Aristarchus......	−47 12	+23 17
Archytas.........	+ 4 13	+58 24	Drebbel	−48 13	−40 47
Cassini A	+ 4 9	+40 23	Marius	−49 57	−11 59
Albategnius ...	+ 3 58	−11 21	Billy	−49 58	−14 0
Werner	+ 2 58	−27 46	Pythagoras	−61 37	+63 4
Conon	+ 1 57	+21 31	Seleucus	−65 48	+20 54
Ukert	+ 1 9	+ 7 48	Crüger............	−66 40	−16 46
Aristillus	+ 1 7	+33 45	Lichtenberg ...	−67 5	+31 25
Murchison A ...	+ 1 0	− 4 4	Eichstädt	−70 27	−20 31
Ptolemaus A ...	− 0 58	− 8 35	Harding	−70 52	+43 9
Herschel	− 2 9	− 5 37	Grimaldi A......	−70 53	− 4 54
Bode	− 2 38	+ 6 38	Olbers	−77 33	+ 7 55

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Meeting of the Royal Astronomical Society on December 10 49
Meeting of the Liverpool Astronomical Society 57

Articles :—

Account of further Observations of the Lunar Crater Plato in 1882–84. By A. STANLEY WILLIAMS, F.R.A.S. 59
Meteor Notes. By W. F. DENNING, F.R.A.S. 65
Selenographical Notes. By THOMAS GWYN ELGER, F.R.A.S. 67

Correspondence :—

Comet Barnard-Hartwig (1886 *f*). By Lieut.-Col. G. L. TUPMAN, F.R.A.S. . 69
Mr. Gore's Nova Orionis. By W. H. S. MONCK, M.A., F.R.A.S. 69
Red Spot on Jupiter. By A. STANLEY WILLIAMS, F.R.A.S. 71
Professor Rigaud. By W. T. LYNN, B.A., F.R.A.S. 71
Montaigne's alleged Observation of a Satellite of Venus in 1761. By W. T. LYNN, B.A., F.R.A.S. 73

Notes :—

Extraordinary Canard.—The Argentine General Catalogue.—The Diurnal Nutation of the Earth's Axis.—Stellar Photography at Harvard College.—Sun-spot Observations at Kalocsa.—The Kalocsa Observatory.—A Correction for Gravity in the use of Refraction Tables.—Death of Dr. Oppolzer.—Names of Minor Planets 74–80

Ephemeris for Comet Finlay (1886 *e*). By Dr. J. HOLETSCHEK 80
Ephemeris for Comet Barnard (1886 *f*). By Dr. AUG. SVEDSTRUP 80

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[A sheet of paper as it came from the cylinder, after being used, was here exhibited and explained.] I believe this chronograph was made in the Melbourne Observatory. I have here a chronometer that will make the seconds' contact, and I shall be able to show you the chronograph at work. I believe a similar instrument is in use at Adelaide Observatory, but Mr. Todd says he has altered the form of recording.

Mr. Dunkin. Is not the American method of registration something similar?

Mr. Buckney. Yes, I believe it is. The main feature is the controlling pendulum, and certainly it appears to answer very well, besides being simple and inexpensive to make. The instrument is now in action, and is recording the second-marks. I think it had better be left, and if I can have a few minutes later in the evening I shall be able to take this paper off and hand it round, and I might put a few observations upon it.

The President. Would any Fellow desire to ask Mr. Buckney any further questions?

Mr. Ranyard. I should like to ask one question. As I understand it, the pen is controlled by the standard clock, whereas the cylinder is driven by the parabolic pendulum.

Mr. Buckney. The rate of the barrel is controlled by the parabolic pendulum.

Mr. Ranyard. If both were controlled by the standard clock it would ensure the lines being straight.

Mr. Buckney. I think the less work you give the standard clock to do the better, and I do not know that it is absolutely necessary to have the records in a straight line. If I may refer you to volume xxxvi. of the 'Monthly Notices,' you will see Mr. Ellery goes into this question rather fully, and he says it has been represented to him that such great precision as to get the lines straight is unnecessary. He thinks it convenient, because it facilitates the measure of the fractions of seconds.

Mr. Ranyard. I should like to know whether there is any method of correcting for temperature. The little springs, not only by their change of elasticity, but by their change of length, ought to make a difference in the going of the clock.

Mr. Buckney. I apprehend it will affect the rotation of the barrel. You see the pendulum is not compensated at all, and I presume Mr. Ellery has not found that necessary. I suppose the instrument would be installed in some place where the temperature is tolerably uniform. It only goes for two and a half hours, and if it is fairly well protected there would be practically no change during that time; and if there were a change, it would be a gradual one, and you would get the second-marks removed a little out of the straight line in the barrel. But it would not be a sudden effect; it would simply alter the space from second to second.

Mr. Ranyard. But it would make a great difference in the going of the pendulum.

THE OBSERVATORY,

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No. 119. JANUARY. 1887.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, December 10, 1886.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel, and
Lieut.-Col. G. L. Tupman.

The Minutes of the previous Meeting were read and confirmed.

Col. Tupman. Sixty-four presents have been received during the month. Calling for special mention is the general Catalogue of Stars from Cordoba as distinguished from the Zone Catalogue received some time ago. The places in the present one are more accurate than in the former. We have also two volumes from Harvard, containing a catalogue of stars observed there. Also I may mention that Mr. Roberts has sent us a photograph of which he showed us rough proofs at the last Meeting

Votes of thanks to the donors were passed.

On the motion of Mr. Inwards, seconded by Sir James Cockle, Messrs. Lecky, Sadler, and Bryant were appointed Auditors of the Society's accounts.

Mr. Buckney then described the action of a chronograph sent by Mr. Ellery, of the Melbourne Observatory, for the purpose of being exhibited in the late Colonial Exhibition. He said: The principal feature of this chronograph is the controlling apparatus, which is a modification of Huygens's parabolic pendulum. The parabolic pendulum was first described by Huygens; and this particular apparatus is very fully described in 'Monthly Notices,' vol. xxxvi. p. 72. The merit claimed is that the form of the governor, viz. the parabolic pendulum, secures a practically uniform rotation of the cylinder, so that the marks made at every second of each minute shall be practically in a straight line from one end of the cylinder to the other, the cylinder being adapted to register for two hours and a half.

the conclusion that he was mistaken in thinking he had observed true bright lines, because I cannot see how it is possible for any bright lines that really belong to the star to escape widening out by the cylindrical lens when all the rest of the spectrum is so widened out.

Another point is with regard to the width of the slit. Mr. Sherman's slit was six minutes of arc in width. The diffraction-disk of his star, he now says in his paper, would be about three seconds. I objected to so wide a slit on the ground that it was practically no slit at all—that it was one hundred times too wide; but he still urges that my criticism was unfounded, although, of course, a slit only the one hundred and twentieth part as wide would have allowed the entire diffraction-disk of the star to be seen. The point I objected to was not that it was impossible to see the spectrum through so wide a slit, but that his measures would have no value at all, because unless he knew where the star was on the slit, it might move from one jaw to the other, and consequently his bright lines would move correspondingly in the spectrum. He measured lines in the spectrum of some stars, some of which were so near each other that the motion of the star from one side of the slit to the other would probably cause the lines to shift in their places by more than their distance apart from each other. Mr. Sherman also makes a number of quotations from M. Gothard and Dr. Konkoly as to β Lyræ and γ Cassiopeiæ; but I do not think they are relevant to the point at issue, because I never disputed that there were stars with bright lines in their spectra, but I doubted whether Mr. Sherman had succeeded in doing as he thought he had, viz. detected bright lines in every one of some fifty stars, taken at random, that he had observed. (Hear, hear!)

Mr. Knobel read a paper by *Dr. Copeland* on the Nova Andromedæ. It was stated in the paper that on receipt of a telegram as to a variation in the Nebula, a circular was sent out from Dun Echt and a watch was at once kept. On Sept. 1 it was seen that the centre of the great nebula was occupied by an object like a star of the 7½ magnitude. Only very slight indications of bright lines could be detected with the spectroscope. Micrometrical observations were also recorded. In regard to the spectrum it resembled that of the Great Nebula in that it was continuous, and it also showed feeble traces of bright lines. On Sept. 10 it extended from between B and C to halfway between F and G. By the 15th Sept. the Nova, which was yellow in colour, had fallen in magnitude, and only traces of two lines could be made out. On Oct. 1 those two lines were still fainter. On Oct. 19 the spectrum was still continuous, but not uniform. In regard to magnitude, the Nova was brighter on Sept. 10 than when first observed; it then appeared to be 8·7 magnitude. The estimates of magnitude were given in a table from Sept. 1 (when it was 8·47) to Jan. 2 (when it was 13·5). On Jan. 30 it was not certainly seen; on Jan. 31 it was just discernible; but on Feb. 2 there was no trace of it with a 15-

inch aperture. During the whole period the light followed a generally decreasing scale, but the decrease was not perfectly continuous. The star decreased irregularly, fading more rapidly at first than afterwards. The visibility of the nebula was first measured on Sept. 3, and the results were given in the paper.

Capt. Noble. There seems to have been a rather remarkable difference as to the colour of this star. I examined the Nova on the first fine night after the receipt of the Dun-Echt Circular. I cannot be sure as to the date, I would have looked it up had I known this paper was to be read; but I certainly noted the colour of the star as blue, and my wife, who, though one of the rarest visitors to my observatory, was with me on that occasion, compared its appearance to that of a tiny electric light; so that two persons, the one a practical observer of long experience and the other not a practised observer at all, both independently ascribed the same bluish tint to the star. To my eyes it remained blue for the first few days, and then afterwards it certainly became reddish.

Mr. Ranyard could confirm Capt. Noble in his remark that there was a change of colour in the Nova, and it appeared to him at first as bluish, and afterwards as of a reddish tint as it became fainter.

Mr. Bryant. Did you observe with both eyes?

Mr. Ranyard. No.

Mr. Bryant. I have seen the planet Saturn red with my right eye and of a totally different colour with my left eye.

Mr. Knobel. I can quite confirm what Mr. Bryant says. A planet appears of a different colour to me if I observe it with one eye to what it does when I observe it with the other.

Mr. Sadler. Dembowski made a similar observation with regard to the colours of double stars; viewed with the right and the left eye, the colours appeared to him entirely different.

Mr. Maunder. I thought I detected three bright lines in the spectrum of the Nova, but the positions I obtained for them did not agree with those obtained by Dr. Copeland. At the time I was disposed to identify the lines with the three principal lines of the corona, and I felt the more confidence in my measures since Mr. Sherman, of Yale College, gave positions for the bright lines he had observed in the spectrum of the Nova, which agreed with mine quite as closely as could be expected. But seeing that I only obtained two rough pointings on one line and one on another, and that I had a smaller aperture than Dr. Copeland, who made a considerable series of measures with a specially constructed spectroscope, I should think his determinations must be worthy of more confidence. I see, however, that he again speaks of the stellar spectrum of Secchi's third type as being that of bright carbon. I cannot agree with him there. I think that our knowledge of the type quite precludes that interpretation being placed upon it. In this particular instance we should have, according to Dr. Copeland's view, a star very greatly increasing in brilliancy, and yet the bright bands in its spectrum are discernible only with the greatest difficulty. If, therefore, the increased brilliancy of the star was entirely or even largely due to these bright carbon bands, it is difficult to understand how it should have increased so much in magnitude and yet that the bright bands themselves should have been seen with such great difficulty.

Col. Tupman read a note on Erratic Meteors, by *Mr. B. J. Hopkins.* The writer stated that in November 1885 he read to the Society a paper containing a series of observations on a class of meteors which, from the apparent form of their paths, he had termed erratic. The appearance of these bodies was comparatively rare, inasmuch as of the 1300 meteors which Mr. Denning had observed during 1885, only 4 were erratic. He observed on December 4, at 18 hours, a meteor which in its path appeared to break in two. It was of a brilliant white colour, and equalled Jupiter in apparent magnitude; it first made its appearance near Ursa Major. As it proceeded, the meteor seemed to divide and the remainder of its path was continued at a short distance, about 30°, above the level of the path pursued at its first appearance, though parallel to it. On one or two occasions before he had noticed a break in the path of a meteor, but looked upon it as an optical illusion or as fancy; but such an appearance would be caused probably if at the point of disappearance of one meteor another made its appearance. In the case he was now referring to, the meteor was of slow motion and was visible for two seconds, and he was confident it was not an illusion. The slight curve in the path of the meteor might be accounted for by Mr. Ranyard's suggestion of an irregularly shaped meteor, but that would not account for the break in the path. Mr. Denning accounted for it by variations in the light of the meteor; but this meteor did not vary in brightness, and was therefore different from those Mr. Denning had observed. Whatever caused the meteor to change its course seemed also to have caused the momentary disappearance of the meteor. It was in the hope that some explanation of the phenomenon would be forthcoming that he had sent this note to the Society.

Mr. Ranyard. I have never seen one of these broken-pathed meteors, but there seems to be an accumulation of evidence that such paths are occasionally observed. Assuming their existence, I think they might be accounted for by supposing that the meteor had a projection upon it, causing it to skid to one side from its original direction, and that this projection was broken off or destroyed. The resistance offered by the atmosphere would be entirely changed and it would suddenly begin to skid in a new direction. If, for example, the meteor were like a ball with two projecting wings, or a mass with two crystalline spicules projecting one on either side, and one of them was destroyed through the heat due to the friction of our atmosphere, the body would begin immediately to skid in a new direction.

'apt. Noble. Does Mr. Hopkins say that this meteor had any l?

'ol. Tupman. No, he says it was a small one without any ak, and after going a short distance it changed its direction; the intermediate part was not seen. It is evident to me that e were two distinct shooting-stars.

apt. Noble. I asked the question because I did not know ber Mr. Hopkins, perhaps, not having observed many meteors, ok a curvature of the trail, which I have frequently observed, he meteor itself having followed a broken path.

l. Tupman. Oh, no! Mr. Hopkins describes two straight s, one over the other, like two separate shooting-stars, as I no doubt they were.

r. Bryant. An appearance such as Capt. Noble has spoken of seen by me last November. I was crossing Newmarket Heath a meteor seemed to fall almost at an angle of 45° to the horizon. meteor was extinguished, but a small trail left assumed the e of a sickle. It was scarcely equal to a semicircle, it was like half an ellipse.

l. Tupman. The late Julius Schmidt, of Athens, has drawn ral such curved trails. I once saw such a trail for two hours. eors following bent paths are seen from time to time, but the or would not, in such a case, move in two different planes. It common thing for a meteor to disappear entirely in the middle s course, and reappear again further on, but the path is all in line.

Ir. Ranyard. Or there may be some small cloud between you the meteor. The explanation I gave, however, was not inded to explain the sort of path Mr. Hopkins describes, but a h with an angle in it.

'ol. Tupman (referring to the chronograph which *Mr. Buckney* had ibited) said: There is one point in connection with this instrunt to which attention should be called, and that is the chronoter which is making the second-breaks in the instrument. This the first time that a second break-circuit chronometer has been de in England. Messrs. Dent & Co. have made three, and this the third one.

The President. We have now finished all the formal communitions to be brought before us to-night. I would ask if any llow has any verbal communication to make to us.

Mr. Ranyard. I should like to mention, Mr. President, a tter connected with the paper I read at the last meeting on the diation-area of the rich group of meteors observed on November th last year. It has been assumed by several meteor-observers at on such occasions only a small amount of matter comes into e atmosphere—that the brightest meteors of the first, second, d third magnitude are only minute grains not larger than musrd seeds. Most meteors are seen at a distance of considerably er 100 miles, and assuming a first-magnitude star to be a little brighter than a standard candle at a distance of a mile, an electric light of 10,000-candle power would only appear, at the distance of 100 miles, equal to the brightness of a first-magnitude star; therefore we should want an electric lamp giving a light of 100 standard candles to match a sixth-magnitude meteor only just visible to the naked eye, and a light fainter than 100-candle electric lamp would not be visible. I think we may safely deduce from this comparison that the meteors we see equal to sixth-magnitude stars are larger than the portion of carbon that is made incandescent in the lamp of 100-candle power, because carbon is very refractory, and when it is being driven into vapour it gives more light than any other substance yet experimented with. If metal or stone were driven into vapour by electricity, it would not give so much light as the carbon used for electric light purposes. We may safely, therefore, assume that the body that is giving us this incandescent light is larger than the ends of the carbon which are rendered incandescent in an electric lamp that gives 100-candle power; so that the meteors of sizes varying from the sixth magnitude to the first magnitude will involve the entry into the Earth's atmosphere of a great quantity of matter, without taking into account the immense number of smaller particles which would only be visible as telescopic meteors. I should like to lay this suggestion before the Society in order that it may receive criticism, for it is a matter of importance how much meteoric matter falls on the earth. If I am right, a much greater quantity of matter may come into our atmosphere without our being aware of it than has hitherto been supposed.

Col. Tupman. At what distance would a standard candle become invisible to the naked eye?

Mr. Ranyard. I should say that it would be just visible at about 10 miles, and a lamp of 100-candle power would be visible at 100 miles. And then a meteor which appears like a sixth-magnitude star must be brighter than such a star, because it is moving over a large arc; and in order to influence the retina of the eye it must be brighter than a point of light that remains stationary. This all leads to the fact that a still greater quantity of matter is necessary to be rendered incandescent in order to appear as bright as a sixth-magnitude star; and another consideration is that the matter as it passes through the air is subject to great pressure, which would tend to tear it up rapidly, whereas the carbon in an electric lamp is not subject to such pressure.

Col. Tupman. Surely it would take less matter in a moving body than a stationary body!

Mr. Ranyard. No; in order to be seen as a line of light it would need a brighter body.

Col. Tupman. I think it is just the other way.

Capt. Noble called attention to the fact that a pamphlet had been presented to the Society, by a person whose name he had forgotten, professing to demonstrate mathematically that the solar parallax was all wrong. On the titlepage was: "Presented to the Royal Astronomical Society, Jan. 13, 1886," as if the Society had given its authority to the publication. He protested against such a statement going forth to the public.

Mr. Knobel said that the Society had special shelves in the library for paradoxical books [Laughter], and the volume alluded to would go with the rest.

The following papers were also announced:—

J. E. Gore. "Formulæ for Binary Stars."

Sydney Observatory. "Observations of Comets Winnecke and Finlay 1886 made with 11½-in. Equatoreal and Filar Micrometer."

A. Marth. "Ephemeris of the Satellites of Uranus, 1887."

J. L. E. Dreyer. "Second Supplement to Sir John Herschel's General Catalogue of Nebulæ and Clusters of Stars."

Royal Observatory, Greenwich. "Observations of Comet *f* 1886 (Barnard)."

The following gentlemen were duly elected Fellows of the Society:—

Capt. Robert Dowling, Rev. Robert Sparke Hutchings, Rev. Henry Pool Slade, Washington Teasdale.

The Meeting adjourned at 9^h 45^m P.M.

Liverpool Astronomical Society.

The usual Monthly Meeting was held on Monday, Dec. 13. The chair was taken by Mr. H. Hudson. 33 members were elected and 25 candidates proposed, and Messrs. W. Thynne Lynn, B.A., F.R.A.S., and Herbert Sadler, F.R.A.S., were elected Associates of the Society.

Mr. Herbert Sadler, in commenting upon a former paper on the "Masses and Distances of Binary Stars," complimented Mr. Gore on the care and accuracy of his computations, but took exception to the data on which they were founded. Amateurs were too apt to accept such results as absolutely proved, whereas they were matters of great uncertainty. The celebrated star 61 Cygni was a case in point, for although numerous measures of the orbit had been obtained, they were not at the present time sure that it was a binary at all. The calculations of the Astronomer Royal for Ireland gave a parallax of 0″·467 for 61^2 Cygni, whilst Prof. Asaph Hall, by precisely the same method, arrived at a final result of 0″·270. The former would give a light passage of less than seven years and the latter of more than twelve. He merely gave this as an example of the uncertainty attending such investigations.

Mr. W. S. Franks, F.R.A.S., commended the study of coloured stars as in every way suited to beginners with small telescopes.

To the amateur in astronomy, what could be more pleasing than to contemplate the colours of those gems of the midnight sky? The hidden meaning of the colours was in itself a theme for wonder; since why should the richest tints of blue, green, and violet be confined to the companions of double stars? That they were not the effect of contrast, was proved by occulting the brighter star. The bluest of isolated stars was Vega, which many would not consider blue at all, and the greenest, β Libræ; but it was only when they came to such stars as β Cygni, γ Andromedæ, and others that the most gorgeous colours were obtained.

In a paper "On the Quadrantid Meteors," Mr. T. W. Backhouse, F.R.A.S., said the ensuing shower would occur under fairly favourable circumstances on the 2nd January, though, as the maximum would take place in daylight, observers in this longitude would not be fortunately situated. Next to the August Perseids, the new year's display of Quadrantids, with their brilliant streaked appearance, was most interesting. Their time of maximum was, however, shorter than most periodical displays, and this rendered an exact calculation of their period important.

Mr. W. F. Denning, F.R.A.S., attributed a special value to the notes of Mr. Backhouse. His table of results for last January proved the shower to have been decidedly conspicuous, though, at Bristol, it could not be seen to any advantage. On January 2 he had watched the sky whenever a break in the clouds permitted, and had counted 17 shooting-stars, of which only four were Quadrantids. Of course this was under unfavourable conditions, and Mr. Backhouse's results afforded clear evidence that it was a fairly bright display. He had determined the radiant at 228° +52°, but the paths had been too few to obtain a reliable average. The mean point of divergence from a considerable number of radiants by other observers gave 230°·5 +51°·3.

A paper by Mr. J. E. Gore, F.R.A.S., was read, on some suspected variables of the Algol type. This class of variable stars was a very rare one, only seven having been detected. They were in order of right ascension:—

Star.	Period.	Variation.
	d	
U Cephei	2·49132	7·2 to 9·1 to 9·4
β Persei (Algol) ..	2·86727	2·2 to 3·7
λ Tauri	3·952	3·4 to 4·2
S Cancri	$9^{d}\ 11^{h}\ 37^{m}\cdot 75$	8·2 to 9·8 to 11·7
δ Libræ	$2^{d}\ 7^{h}\ 51^{m}\ 20^{s}$	4·9 to 6·1
U Coronæ	$3^{d}\ 10^{h}\ 51^{m}\ 14^{s}$	7·6 to 8·8
U Ophiuchi	$0^{d}\ 20^{h}\ 7^{m}\ 41^{s}$	6·0 to 6·7

Owing to the fact that, in these remarkable variables, all the light variations took place in the course of a few hours, whilst for the remainder of the period it remained constant, it would be seen that the discovery of this class was a matter of great difficulty, and this would, he thought, account for the paucity of such stars amongst the many thousands known to astronomers.

Mr. T. G. Elger, F.R.A.S., in a third paper on "The Moon surveyed in Common Telescopes," dealt with Gassendi and the eastern side of the Mare Humorum, describing in detail the various points of interest which might be observed under good conditions with very moderate telescopic means. The remarkable peculiarities of Gassendi itself, its low and attenuated state on the south-east, and the degradation of a great portion of its northern wall were worthy of scrutiny. The complicated structure of the magnificent central mountains, which had been compared by the late Prof. Phillips to an associated group of dolomitic or trachytic rocks, together with points of interest in the neighbourhood, were illustrated by a number of autographed sketches, which the members were advised to compare with the actual appearance in their own telescopes.

A paper on the present and future of celestial photography by Monsieur Lihou was also read, and Mr. W. F. Denning contributed the third series of his valuable papers on Telescopes and Telescopic work.

Account of further Observations of the Lunar Crater Plato in 1882–84.

The Spots.

In the 'Observatory' for March, 1883, will be found a short account of some observations made upon the markings in the interior of the large walled plain Plato in the Moon, in the course of the years 1879–82, by several observers. At the end of this account it was stated that the observations were being continued with increased vigour. It is now proposed to describe some of the principal results derived from the continuation of the observations of Plato in the period extending from 1882 March 27 to 1884 Feb. 11 (inclusive), comprising an interval of 24 lunations. As the observers commenced operations with already about three years' experience in observing and drawing the light spots and markings upon the floor, it is considered that additional value should be attributed to the present series, as they were all consequently well acquainted with the positions and usual forms and brightnesses of the principal features—experience with this and other formations having shown that a period of at least two years is required for an observer to thoroughly familiarize himself with the most delicate detail of the lunar surface. An account, therefore, of some of the principal results obtained from the reduction and discussion of these observations will, it is hoped, be of some importance, not only in indicating the aspect and condition of the markings upon the floor at the time when they were made, but also, by comparison with the corresponding series of observations in 1879–82 and 1869–71, in pointing out some of the changes which have happened in the state of the floor of Plato. It is proposed at present to confine the attention to the subject of the light spots upon the floor, reserving the particulars relating to the no less important light streaks and markings for some future occasion.

The observations in the period from 1882 March 27 to 1884 Feb. 11, which may be for convenience termed the "Second Period" (that of 1879–82 being designated the "First Period"), were made by the following observers:—the Rev. F. B. Allison at Chesterfield, with a 4½-in. refractor; Mr. T. P. Gray at Bedford, with an 8½-in. reflector; and myself at West Brighton, using a 5¼-in. reflector and a 2¾-in. refractor. To these two gentlemen I am greatly indebted, not only for numerous carefully made observations, but also for much kind assistance and advice. An observation by Mr. S. M. B. Gemmill towards sunset has also been included. The total number of spots seen during the Period was 50. Of these, 13 were discovered in the course of the observations, and have been observed on at least two nights each, though most of them were seen much more frequently. The total number of spots which have now been observed upon the floor has consequently been raised to 57. It is a matter of some interest that, notwithstanding the close scrutiny which this portion of the Moon's surface received in the course of the years 1869–71, no less than 20 new spots should have been discovered since that time; yet the instruments then made use of were no whit inferior to the present ones. Three of the old spots seen in the First Period were not observed in the Second (Nos. 2, 21, and 23); but, on the other hand, two spots not seen in the First were detected in the Second Period (Nos. 27 and 28). There are therefore now only four of the old spots observed in 1869–71 which have not been redetected. These are Nos. 8, 10, 29, and 35.

The following Table gives the *mean visibilities* of the spots for the period 1869–71, as calculated by Birt, and for the First and Second Periods, and thus shows at a glance the changes which have happened in the brightness or visibility of the spots. The visibilities of the Second Period (1882–84) are derived from 1978 observations of the spots, the greatest number seen on any one night being 33, and the average number seen on each night being 11·3. It will be noticed that the average number of spots seen per night is thus greater than it was in the First Period (8·4). This will be accounted for by the greater familiarity of the observers with the markings. 93 drawings and sketches of the features on the floor were also obtained in the Second Period, and 1736 observations of the streaks.

TABLE OF MEAN VISIBILITIES OF THE SPOTS.

No. of Spot.	Mean Visibilities in			No. of Spot.	Mean Visibilities in		
	1869–71.	1879–82.	1882–84.		1869–71.	1879–82.	1882–84.
0	·044	·031	·024	29	·035	......	......
1	1·000	1·000	1·000	30*	·166	·306	·270
2	·039	·022	......	31	·026	·031	·037
3	·904	·865	·715	32	·070	·077	·048
4	·891	·977	·907	33	·013	·018	·028
5	·528	·540	·480	34	·022	·045	·048
6	·214	·297	·391	35	·004	......	......
7	·105	·113	·163	36	·004	·009	·004
8	·013	......	......	37	......	·004	·015
9	·218	·275	·244	38	......	·104	·154
10	·057	......	......	39	......	·068	·233
11*	·144	·022	·041	40	......	·018	·061
12*	·026	·351	·320	41	......	·018	·065
13*	·148	·401	·272	42	......	·022	·052
14*	·432	·667	·487	43	......	·009	·137
15	·017	·027	·002	44	......	......	·065
16*	·293	·189	·100	45	......	......	·009
17	·838	·784	·822	46	......	......	·009
18	·083	·027	·007	47	......	......	·026
19	·135	·162	·065	48	......	......	·007
20	·039	·027	·063	49	......	......	·007
21	·022	·004	......	50	......	......	·041
22*	·170	·509	·433	51	......	......	·013
23	·048	·013	......	52	......	......	·004
24*	·048	·261	·202	53	......	......	·009
25	·144	·122	·004	54	......	......	·013
26	·004	·013	·028	55	......	......	·013
27	·009	......	·013	56	......	......	·002
28	·004	......	·007				

Some points of considerable importance and interest may be gathered from this Table. In the 'Observatory' for March 1883, I called attention to the close agreement in the visibilities of the spots for 1879–82 when compared with those of 1869–71, if eight spots, Nos. 11, 12, 13, 14, 16, 22, 24, and 30, which had apparently altered greatly in brightness, were excluded from the comparison. Now, on comparing *all* the visibilities of the Second Period with those of the First Period, including these eight spots*, the average difference is found to be ·049, the smallness of this difference thus showing that the spots in the Second Period had, in general, preserved nearly the same brightness which they possessed in the First Period. If we then compare the visibilities of 1882–84 with those of 1869–71, but now excluding these eight specified spots, the average difference is only ·039. From these comparisons the following four important particulars may be derived:—(1) That the *mean visibilities* of the Second Period agree closely with those of the First. (2) That the eight spots which seemed in 1879–82 to have changed so much in brightness since 1869–71 have maintained, in general, nearly the same change in 1882–84*. (3) That although these eight spots have so maintained, in general, their alteration of brightness, they have nevertheless undergone since the First Period greater changes than the generality of the spots. The average difference in the visibilities of these eight spots amounts in fact to ·077, although that for all the spots is only ·049. (4) That the visibilities, when based upon a large number of carefully made observations, extended over considerable intervals of time, and properly reduced, are capable of showing, with a high degree of exactness, the actual relative brightnesses of the spots, and hence any changes which may happen therein.

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* Spots 25 and 43 have been excluded from these comparisons, because it is certain that they have been confounded. No. 25 is properly situate on the light streak *l* and 43 on γ. But it has only recently been discovered that these two streaks are undoubtedly identical as regards their eastern portions, streak γ being continued on to spot No. 6, and *l* curving round to No. 4. The new spots discovered in the Second Period have likewise been excluded.

The results of the recent observations are thus strongly confirmatory of the view of actual change having occurred since 1869–71, which view is further strengthened by the circumstance that the eight particular spots, to which attention was directed as having changed so much, have again, from a new series of observations, apparently suffered greater changes in brightness than the generality of the spots, which peculiarity would seem to indicate that they are still in a state of change. It is also evident, from the general agreement between the visibilities of the First and Second Periods, that at the same time additional support is given to the accuracy of the method of observation and reduction, and that when the observations are extended over a period of not less than two years, the *mean visibilities* derived therefrom represent very nearly the actual brightness of the objects during that period, and therefore may safely be considered capable of affording in general trustworthy information as to the changes in brightness which the spots may undergo in long intervals of time. To illustrate the accuracy of the method, if we assume the brightness of the central spot No. 1 to be unity, the average difference between all the visibilities of the First and Second Periods is ·049, which represents less than $\frac{1}{20}$ of the interval from the brightness of spot No. 1 to invisibility; and whoever will examine Plato through the telescope at about the time of full Moon, and try to divide the interval between the brightness (or, rather, plainness) of this spot and the general surface of the floor (or invisibility) into 20 parts, will be able to appreciate the accuracy of the method. Even in a telescope of nsiderable size, the brightness (or plainness) of spot No. 1 is t so great as to cause much emotion in the observer. Yet if we re to reject certain spots from the comparison, as we legitimately ght do, the result would be considerably more favourable to the actness of the method.

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* This will be seen at once from an inspection of the preceding Table, when it will be found that all these eight spots (marked by an asterisk) have preserved more or less closely the same visibilities which they had in 1879–82, with the single exception of spot No. 14, which has subsided almost to the same degree of brightness which it possessed in 1869–71.

Having now considered some of the general results, it will be oper to attend to those of the individual spots which seem de-rving of more particular notice; and first the eight spots Nos. 11, , 13, 14, 16, 22, 24, and 30 will claim our attention *.

11. This spot has maintained its great decrease in brightness, ving scarcely altered since 1879–82. It was not seen by r. Pratt in 1873–74, so not improbably it first became fainter a ng time ago.

12, in the opposite direction, has preserved very nearly its *crease* in brightness. Some idea may be afforded of the effects this increase from the fact that in the Second Period it was served on 95 occasions, and in the First Period on 78. Yet in e celebrated survey of 1869–71 it was only seen *six times*!

13, though much brighter than in 1869–71, has yet undergone a nsiderable diminution in brightness; and it is not improbable at it will be found to have diminished still further in the Third riod, now drawing to a close.

14 has been reduced, by ·180, to very nearly the brightness hich it possessed in 1869–71. It is remarkable as being the only e of these 8 spots which has returned to its former degree of ightness. Some curious changes in the appearance of this object ve been noticed of late. A small spot, No. 52, was observed st east of it on Sept. 16, 1883, and again on the following night d on April 9, 1884, on all three occasions the new spot being uch smaller and fainter than the old one. On Oct. 5, 1884, 4 was seen clearly double and was not very unequal as to its mponents; but here 52 was both *larger* and *brighter* than 14. his arrangement was also the same on Oct. 6 and 8 following. ll these observations were made with the same instrument, a ¼-in. Calver reflector. So that here there was a complete change n the relative brightness of two adjacent spots. As spot 14 has eemed fainter during the last two or three years, it is probable hat there will be a still further decrease in visibility in the Third Period.

16. This spot has undergone a steady decrease, having been ·293 in 1869–71, ·189 in the First, and ·100 in the Second Period.

22 has maintained nearly its considerable increase of brightness, and so have Nos. 24 and 30.

Amongst the remaining spots there are two which appear particularly deserving of notice, on account of the *continuous* change which they have undergone; these are Nos. 3 and 6. The former has declined from ·904 in 1869–71 to ·865 in the First and ·715 in the Second Period. The latter, from ·214 in 1869–71, has increased to ·297 in 1879–82 and ·391 in 1882–84.

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* Besides the notes and remarks on particular spots which now follow, the descriptions given in the 'Observatory' for 1883, pp. 87–89, may be referred to.

5. The small decrease in visibility of this spot may be ascribed to the discovery of the neighbouring spot, No. 38.

15 has been completely invisible lately, although carefully searched for.

19. In the First Period this spot had increased slightly in visibility, but it has now suffered a decline.

39. The increase of this spot must be attributed to its not having been discovered until late in the First Period, when it was nearly equal in brightness to spot No. 13, as it still is.

50. A remarkable spot. On February 15, 1883, the Rev. F. B. Allison, observing with a 4½-in. Wray refractor, saw a spot "which seemed west of 3, while 3 itself could not with certainty be made out. It seemed directly N. of 1, as far off as 3." This spot has been seen on eleven nights altogether. It is curious that it should have been discovered when the usually much brighter spot 3 could not be seen.

In the 'Observatory' for 1883, p. 87, will be found a plan of the markings on the floor of Plato, in which the position of most of the light spots are indicated with a considerable degree of accuracy. Of the remaining new spots, No. 44 lies just east of 22, 46 north-west of 17, 51 just west of 41, 52 east of 14, 53 south-east of 6, 54 east of 39, and 55 just east of 13. All these spots form close pairs, or double spots, with those spots contiguous to which they lie. In fact, the tendency of the spots, in Plato as elsewhere, to collect in pairs and groups is a significant circumstance which must not be forgotten when considering the origin and nature of these interesting little objects.

In the beginning of the Second Period a new method of observation was adopted, which, increasing greatly as it does the accuracy of the results, may be recommended for adoption in similar cases. The brightness, or plainness, of the spots is registered according to a recognized and definite scale, in which spot No. 1, at its usual plainness at about the time of full Moon (at which time its brightness remains substantially constant), is assumed as the standard. The effect of this refinement in the method of observation is to nearly double the numbers available for calculating the *mean visibilities*, whilst it is not going too far to affirm that the accuracy of the results is quadrupled. The adoption of some method of this kind becomes absolutely essential in cases where the observations are extended over periods of many years; for where, as with the old method, the spots seen at each observation of Plato are merely recorded, after two or three years the observers become well acquainted with the appearance and situation of the different markings, and it will happen that a large number of spots will be recorded on nearly every night of observation, and hence that many of the fainter objects will receive a fictitious increase in visibility.

In concluding, I wish to call attention to the *strength* of the evidence now existing in support of *real changes* being in course of process in the interior of Plato. Where the observations are so numerous and are extended over so many years, and at all times of the lunation, as is the case with Plato, the baneful influences of libration, atmospherical influences, and differences of illumination may safely be considered to be eliminated, except perhaps in the case of spots which are only visible under certain very confined conditions of libration or illumination, and of which there is little evidence that any such exist upon the floor of Plato.

West Brighton, 1886, Nov. 8. A. Stanley Williams.

Meteor Notes.

Observations were obtained on Nov. 16, 17, and 18, and 47 meteors were seen during 7 hours' watching on the three nights. The most active display was from 54° +71°, which coincides with γ Camelopardali. On Nov. 17 at $8^h\ 52^m$ I noted a stationary meteor projected on this star, making it bright and giving it a blurred appearance. Another meteoric star, perfectly motionless, was recorded at $6^h\ 36^m$ the same night at 284° +43°, and this may possibly have been a late member of the shower at 283° +43°, Oct. 18–29 (Greg and Herschel).

On Nov. 29, observing for 4½ hours between 9^h and 15^h, I counted 43 meteors, and on Nov. 30, in 5 hours, chiefly between 10^h and $15\frac{1}{2}^h$, 57 were recorded. On the first few nights of December I saw 36 additional meteors in watches covering 3½ hours. Of the 100 meteors noted on Nov. 29 and 30, not one belonged to the radiant of the Andromedes (Biela's comet). Before Nov. 29, the nights were overcast, for between Nov. 20 and 28 there was an anticyclone with the usual accompaniment of calm and cloudy weather. Circumstances have prevented anything being seen at this station either of the Leonids or Andromedes.

A considerable variety of minor streams were derived from my observations on Nov. 29–30 and early in Dec., of which the more pronounced are included in the subjoined list:—

No.	Radiant 1886.	Notes and Comparisons.
1	27° +71°	Observed in 1885 at same point and epoch (D.).
2	61 +37	Seen also in 1877 (D.). Heis, 66° +34°, Dec. 3–11 (30 meteors).
3	64 +23	Late Taurids. At 63° +21°, Nov. 27, 1880 (D.).
4	81 +22	ζ Taurids. Active shower of slow meteors.
5	105 +11	Near β Canis Minoris. Seen by Schmidt in Dec.
6	136 +77	Meteors swift. Feeble shower.
7	142 +50	Obs. in 1885 at 143° +48° (D.). G. & H. give 139° +53°, Dec. 13.

No.	Radiant 1886.	Notes and Comparisons.
8..	162° +58°	Obs. in 1885 at 161° +58° (D.). G. & H. give 160° +60° Nov.–Dec.
9..	190 +58	Obs. in 1879, Nov. 13, at 191° +58° (D.).
10..	190 +79	Backhouse gives 206° +76°, Dec. 10.

Nos. 7, 8, and 9 are radiants in Ursa Major, severally near θ, β, and ε. They discharge meteors with streaks and moving with great velocity. No. 5 was well-defined at a point from whence, in preceding months, a succession of numerous showers is directed. 20 radiants observed between Sept. 15 and Jan. 15 give a mean place at 107° +11°·5, but no one can say how many different streams are involved in the lengthy sustenance of the radiant, and we are equally ignorant as to their individual periods. The fireball of Nov. 16, 1862, had a radiant at 110° +8° (A. S. Herschel) and was probably a brilliant representative of these Canis Minorids.

Fireballs.—On Dec. $4^d\ 9^h\ 17^m$ a fireball = ♀ was observed at Bristol near γ Ursæ Majoris. It left a streak only ½° long at the point 188° +50½° for 1½ minute. The meteor probably belonged to the radiant of β Ursids at 162° +58°. This fireball was seen at Stonyhurst College near Whalley, and its path was described as from 27 Lyncis to θ Geminorum. There was a bright streak left, involving the former star, for 1½ minute. The meteor passed over Yorkshire at heights from about 65 to 28 miles, and the luminous streak lay above a point near Thirsk, at an elevation of some 45 miles.

In our last month's "Notes," reference was made to the brilliant fireball of Nov. $17^d\ 7^h\ 18^m$, but the published observations are imperfect and to some extent discordant. The best result derivable from their comparison is that the meteor first appeared over a point W. of Hitchin, Hertfordshire, at a height of about 96 miles, and from thence it travelled slowly to W.N.W., until the point of extinction 5 miles N. of Cleobury Mortimer, Shropshire, at an elevation of 21 miles. It traversed 119 miles in 7 seconds (carefully determined at Bristol), so that its orbital motion was 17 miles per second, which agrees very closely with parabolic velocity. The native speed of the fireball would be probably retarded in some degree by the resistance of the atmosphere and accelerated by the Earth's attraction.

Its path was inclined to the Earth's surface at an angle of 40 degrees, and had the meteor continued about 31 miles further, it would have fallen at a point W. of Church Stretton, and on the S.W. border of Shropshire.

In order to reconcile the observations, it becomes necessary to alter the direction as given by an observer in Lancashire. The notice from Kensington is too indefinite for use, the description being that the meteor descended from near the zenith, and fell perpendicularly through Ursa Major. It must, however, have fallen from N. of the zenith and been inclined to W.

The radiant-point was probably a few degrees S.E. of α Arietis, at 34° + 19°. On the nights of Nov. 4-7, 1877, I observed a shower from 30° + 16° which may perhaps be the same, but the agreement is not good as to node.

For the above approximate heights, &c., I have mainly relied upon my own observation of the fireball as it was seen under exceptionally favourable conditions, and I can trust the points of beginning and end to within about ½°. W. F. Denning.

Bristol, 1886, Dec. 8.

Selenographical Notes.

Mädler.—This small ring-plain, so conspicuous from the brilliancy of its surroundings under a high angle of illumination, presents many points of interest to the observer when examined with moderately high powers and under suitable conditions. Some years ago the late Mr. Birt drew attention to the remarkable ridge which, apparently forming an extension of a crater-row north-east of Isidorus, runs up to Mädler and, breaking through the north border, traverses the floor in a meridional direction nearly to the inner foot of the opposite wall. He pointed out that this very suggestive phenomenon was not shown on any existing lunar map, and regarded it as a subsequent formation to the seemingly disturbed ring. It is somewhat strange that so striking a feature should have been overlooked by Lohrmann, Beer and Mädler, Neison, and Schmidt; but this is perhaps accounted for by the fact that to see it satisfactorily it must be viewed under a very low Sun, though when one becomes familiar with it, it may just be traced when the Sun's altitude is equal to 40° or even more. It is best seen under low evening illumination. On the 17th of last September, when the west longitude of the evening terminator was about 32°, a good view was obtained not only of Mädler itself and the ridge, but of the curious region lying to the west. The interior was filled with shade, and the conical shadow of the brilliant west wall extended at $11^h\ 30^m$ to a distance on the plain about equal to the apparent diameter of the ring. There was an evident break or gap in the northern section of the wall through which the ridge was easily traced, bounded on the west by a pronounced shadow and on the east by a large dark crater which stands near the outer foot of the wall. It is clear that the ridge is of considerable altitude, as it was visible for some distance within the formation standing up above the black shadow.

On the 2nd and 4th November, under a much higher sun, it was also traced through the gap. On reaching the interior it appears to swerve slightly to the west, and running parallel to the central mountain joins the latter at its south extremity. The peculiar relation which exists between Mädler and this ridge seems to show that the latter, as a more recent formation, has forced its way through the wall of the once complete ring-plain and partially invaded the floor. It is difficult to account for the appearances presented if we regard the ridge as of alluvial origin; it is more probable in this, as in many other cases, that it represents a "fissure eruption" somewhat similar to those which geologists have recently brought to light in the vast lava plains of Idaho, in the Deccan, and elsewhere.

The ridge is otherwise interesting as affording a good instance of a probable landslip on its eastern flank. The best time for seeing this is when the west longitude of the morning terminator is about 12° or 13°. With good definition and a power of 284 on my 8½-in. Calver reflector, I find traces of two or three irregular terraces on this side and an outward extension of the base of the ridge, which seems to be due to a slipping of the material and an accumulation of the débris at the bottom.

Though the region west of Mädler is virtually a blank as regards conspicuous objects, when it is scrutinized towards lunar sunset the configuration of the ridges is very noteworthy. There is a marked tendency to circular forms, and in two instances something very much resembling a complete but degraded walled plain is exhibited. Two of these contiguous ridges include a rill-like valley, which, under a moderately high light, has all the appearance of a true rill: it is situated in S. lat. 11° and W. long. 33°.

Between the Mädler ridge and the north-west wall of Theophilus there are many small elevations, some of which were recorded as crater-cones on September 17. No lunar formation undergoes a greater transformation than Mädler between sunrise and full Moon. The inherent brilliancy of the western section of the wall, as contrasted with the nebulous dimness of the opposite and really more lofty eastern border, and the conspicuous brightness of the obtuse-angled ridge on the west of the formation, so prominently brought out in lunar photographs, become more and more noticeable as the Sun increases in altitude. No trace of the ridge which has disturbed the continuity of the north border is apparent under a high light, though the southern portion of it seems to form the boundary-line between a region of silvery brightness encircling Mädler on the north and west and the grey-toned Mare west of Theophilus. This line of demarcation extends through Mädler, so that at full Moon the western half of the floor is bright white and the eastern dusky grey, relieved by two brilliant spots representing the central mountain and part of the intrusive ridge. The crater on the north wall is also distinguished by a brilliant oval spot. THOMAS GWYN ELGER.

Kempston, Beds.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Comet Barnard-Hartwig (1886 *f*).

GENTLEMEN,—

The Comet was observed on Dec. 18 and subsequent fine nights with the 18-inch reflector. It passed its perihelion on Dec. 16, and is a fine object, the coma being fully 6 minutes in diameter, fading away gently from, and symmetrically around, an almost stellar nucleus. As clouds pass over it, the nucleus fades away to a fine point, precisely as happens with a bright star. On Dec. 19 the comet was very near the 6th-mag. star Ll 33895, and in broad daylight, only a few minutes after sunset, I had the two objects in the field together, the coma appearing to have a diameter of about one minute. The nucleus was then seen to be about the seventh magnitude, being greatly inferior to the sixth-magnitude star. No envelopes were seen then or at any other time. When it was dark the head of the comet was compared with stars near it by the aid of binocular glasses. It was judged to be exactly equal to ε Aquilæ; about equal to 110 and 111 Herculis; brighter than 72 Ophiuchi, which, however, was already in the mists of the horizon. The principal tail was traced for 7° in the direction of β Lyræ; narrow, straight, and very faint; scarcely anywhere wider than the diameter of the head.

G. L. TUPMAN.

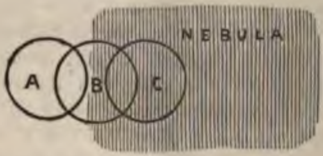
Hillfoot Observatory, Harrow,
1886, Dec. 24.

Mr. Gore's Nova Orionis.

GENTLEMEN,—

Now that Mr. Gore's Nova Orionis has been found to be a variable star with a period of nearly a year, the question why it was never observed until Mr. Gore detected it on the 13th of December, 1885, possesses considerable interest; for it seems pretty certain that its annual maxima cannot hitherto have been as large as they are now without attracting the notice of more than one astronomer. An explanation of the variability occurs to me which would also account for this peculiarity, viz., the intervention of a nebula between the star and the Earth, but so situated that when the Earth is at one extremity of its orbit the line joining the Earth and star passes through the nebula, while, when the Earth is at the other extremity, the joining line passes outside the nebula.

The late Mr. Birmingham (and I believe others) noticed that many variable stars present, when at the minimum, appearances which are most consistent with the intervention of a nebula; but this nebula has hitherto, I think, been supposed to revolve round the star (or the star to revolve round the nebula), whereas, in cases like the present, it seems to me that the star and nebula may be independent of each other, and that the distance between them may be very considerable. To illustrate this, let us suppose a cone formed by drawing lines from every point on the Earth's orbit to the star, and cut this cone by a plane parallel to the ecliptic at the point where the nebula meets it. The section will be a circle. If part of this circle be covered by the nebula and the remainder clear of it, we shall have a variable star with a period of about a year. The period would be exactly a year if the Earth's orbit, the star, and the nebula were stationary, but the mutual proper motions of the three will no doubt occasion some deviation from the annual period. The circle formed by the section of the cone will not be the same year after year, as the cone itself will not be the same, and the motion of this circle may be either into the nebula or out of it. Gore's Nova Orionis on this theory is moving out from the nebula. It has only begun to emerge from it of recent years, and if no change takes place in the mutual motions it will continue to emerge more and more until it clears it altogether. This will be understood by the following diagram :—A, B, and C are three positions of the circular section of the cone, the shaded part representing the nebula ; B represents the present position, C the position some years ago, when the star was constantly at its present minimum, and A its position in some years to come, when it will be constantly at its present maximum. If the period of the star is correctly given as 359·5 days, and this period continues uniform, a little over 60 years would elapse between the first emergence of the star and its finally clearing the nebula and ceasing to be variable. But of course it is possible that instead of clearing the nebula at the maximum, the star only gets in *directum* with a rarer portion of it.



I am encouraged to put forward this hypothesis by the large number of variable stars whose period amounts to nearly one year. Of these I take the following from Mr. Gore's Catalogue :—R Piscium 345 days, S Tauri 378, R Orionis 378·8, R Geminorum 371, R Cancri 354·4, R Leonis Minoris 374·7, R Comæ 363, S Virginis 374, S Serpentis 361, S Coronæ 361, U Libræ 380, R Serpentis 357·6, R Aquilæ 345·1, T Sagittarii 381, R Capricorni 347, T Pegasi 367·5, and R Pegasi 382. Adding Gore's Nova Orionis we have thus 18 variable stars with a period of nearly one year, and to these are probably to be added R Libræ, whose period given at 723 days is probably double the true period, and Y Sagittarii, whose period Mr. Gore gives as $\frac{1456}{n}$ days. Perhaps I might also add : 14782 Libræ 342 days, T Serpentis 342·3, and R Aquarii 388. In several of these stars the light has been observed to be nearly constant for some time at the maximum, which would be a necessary consequence of the star getting clear of the nebula at that period.

I remain, truly yours,

13 Belvidere Place, Dublin.
1886, Dec. 9.

W. H. S. Monck.

P.S.—If a nebulous band or streak crossed the circle in the above diagrams, we should have a variable star with a period of six months. Of this there are probably a few instances, but the half-yearly variables are not nearly so numerous as the annual.

Red Spot on Jupiter.

Gentlemen,—

This object was observed here this morning, and the following are the times when the middle and following end were estimated to be on the central meridian of the planet's disc:—

1886, Dec. 20^{d} 16^{h} 49^{m} centre.
,, ,, 17 24 foll. end.

These times are a little in advance of the Ephemerides of Messrs. Denning and Marth in the 'Companion to the Observatory' and 'Monthly Notices;' but they may be considerably in error, as with a power of about 170 on a $6\frac{1}{2}$ in. Calver reflector the spot was extremely faint and difficult, owing perhaps in great measure to the unfavourable position of Jupiter and the generally bad definition prevailing at the time.

Yours faithfully,

West Brighton,
1886, Dec. 21.

A. Stanley Williams.

Professor Rigaud.

Gentlemen,—

So little is generally known respecting Prof. Rigaud, author of the work on the 'Life and Correspondence of Bradley,' which is familiar to every astronomer, that I persuade myself that a few particulars of one to whom they are thus indebted will be acceptable to many of your readers. Those which I hereby offer are taken from a short memoir by his son the Rev. John Rigaud, of Magdalen College, Oxford, which was not published, but printed privately in 1883, and sent to some of the libraries where the writer thought it would be likely to be useful. It was originally intended to form an introduction to a Life of Halley, which was to have been based on MSS. left by Prof. Rigaud, who unfortunately died before he was able to complete it himself.

Prof. Rigaud was of French extraction, and descended on the father's side from La Brue[*], a famous mathematician and engineer, who in the time of Henry IV. fortified Blaye, near Bourdeaux, and on the mother's side from Colbert, the minister of Louis XIV., at whose instance, it will be remembered, Cassini removed into France, and from the scene of the greatest part of his labours has been looked upon as a French astronomer. The family to which Prof. Rigaud belonged left France on account of the revocation of the edict of Nantes, and one of them (M. de Schirac) ministered to a French Protestant congregation at Bristol. The future professor was born at Richmond on the 12th of August, 1774, and educated at Mr. Delafosse's school in that town. He matriculated at Exeter College, Oxford, when only 16, and was elected a Fellow of his College in 1794, before he was of sufficient standing for a degree. His whole life, so to speak, was spent in Oxford. In 1814 he became Reader in Experimental Philosophy and Professor of Geometry; in 1827 Professor of Astronomy and Radcliffe Observer, which last offices he held till his death in 1839. The work by which he is principally known is the well-known one on Bradley, to which I have already referred, and which will always be a classic in astronomy. It was published in 1831, and the following extract from a letter of Sir Robert Peel, in expressing thanks for a presentation copy (as a Radcliffe Trustee), will be read with interest:—"Politics have not extinguished the deep interest I once took in those higher studies and pursuits to which the life of Bradley was devoted; and I shall turn with the utmost satisfaction from Schedules A and B to the parallax of the Fixed Stars and the Reformation of the Calendar."

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[*] See an article "Dr. Demainbray and the King's Observatory at Kew," in the 'Observatory' for October 1882.

In 1834, Prof. Rigaud communicated to the R. A. S. some facts in the life of Halley from a MS. in the Bodleian Library. Deeply is it to be regretted that he did not live to complete the biography of that great astronomer, for which he had collected, his son tells us, considerable materials, partly with the view of rescuing Halley's memory "from much of that injurious obloquy to which it had been exposed." His eldest son, however (the Rev. S. J. Rigaud, afterwards Bishop of Antigua, where he died), published in 1844 a small work entitled 'A Defence of Halley against the Charge of Religious Infidelity,' which helps to put in a true light some of the remarks which it must ever be matter of regret should have come before the public in a work to which I need make no farther reference at present. But it is with peculiar pleasure, just before the bicentenary of the publication of the 'Principia,' that I call attention to Prof. Rigaud's "Historical Essay on the first publication of Sir Isaac Newton's 'Principia,'" in which there is much interesting matter about Halley, at whose sole expense and risk (let it never be forgotten) that greatest of all scientific works was published. This very able and interesting essay appeared in 1838; on the 16th of March in the following year the author died most unexpectedly in London, in the sixty-fourth year of his age, and was buried at St. James's, Piccadilly. He was succeeded, I need hardly remark, as Radcliffe Observer by the late Mr. Johnson, whose name and scientific labours are familiar to all of us, and who wrote of his honoured predecessor:—"In affectionate regard for his memory and in admiration of his learning I yield to no one. His private virtues are remembered by many of us; and his public services will be remembered as long as Astronomy is a science cultivated among men."

Yours faithfully,

Blackheath, 1886, Nov. 6. W. T. LYNN.

P.S.—The Rev. J. Rigaud (who has recently kindly sent me a copy of his brief memoir of his father) calls my attention to an erratum in his brother's* article in the 'Observatory' for October 1882 (vol. v.). In line 23 of p. 284, "Stephen Peter Rigaud" should be "Stephen Rigaud" simply, the person referred to in that paragraph being not Professor Rigaud (who was born at Richmond), but his father.—W. T. L.

Montaigne's alleged Observation of a Satellite of Venus in 1761.

GENTLEMEN,—

Many of your readers will remember that Mr. Prince, F.R.A.S., of Crowborough, circulated in the year 1883 a pamphlet on the great comet of 1882 and on the transit of Venus, both containing his own valuable observations, as given in the 'Monthly Notices,' with the addition of other interesting matter. As a sort of supplement he gave, from 'The Mathematical Magazine and Philosophical Repository' (a small periodical, of which only one volume, I believe, ever appeared; its date is 1761, and there is a copy in the library of the R. A. S.), an account by Dr. Bevis of a memoir of M. Baudouin on an observation by Montaigne of a supposed satellite of Venus, with conclusions drawn therefrom, together with some remarks on supposed observations of a similar kind by Short and others.

A separate copy of Baudouin's paper is in the library of the British Museum; and it may be of some interest to point out that whatever view we may hold as to a possible satellite of Venus, the observations of Montaigne do certainly not relate to any such body. By comparing them together, Baudouin shows in this paper that assuming them to have been of a satellite, it must have been moving in an orbit very nearly perpendicular to the ecliptic, and revolving round Venus in the period of about 12 days, at a distance of 50 semidiameters of the planet from it. He then proceeds to determine an approximate value of the mass of Venus in accordance with this. In doing so, he takes for the diameter of that planet, compared with that of the Earth, the fraction $\frac{1075}{1558} = 0{\cdot}69$, which, he says, is one of the values assigned by Le Monnier, "sans indiquer cependant de quelle Observation il l'a tiré," in his 'Institutions astronomiques.'

This would make the distance of the supposed satellite from Venus about 35 semidiameters of the Earth; and as a Moon at that distance from the Earth would revolve in about 12 days, Baudouin concludes that the mass of Venus is nearly the same as that of the Earth. But he is constrained to admit that most determinations of the value of the diameter of Venus make it much greater than the above (which implies a volume for that planet only a third part of that of the Earth) and nearly equal to that of the Earth. If this be adopted, the resulting mass of Venus from the alleged motions of the supposed satellite would be three times as great as that of the Earth. I need not point out that it is quite as impossible to accept for Venus a mass anything like this as a volume of only a third part of that of the Earth. Either horn of the dilemma is in fact equally inadmissible.

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* Major-General Gibbes Rigaud, who died very suddenly about two years ago.

It may be worth while in this connection to refer to Lalande's remark ('Astronomie,' § 3077) on the supposed observation of a satellite of Venus by Short in 1741. He states that he had some conversation with that astronomer in 1763, and that he "parut lui-même ne pas croire à l'existence d'un satellite de Vénus, mais plutôt à celle de quelque autre planète qui réfléchissant moins de lumière, ne se voyoit que difficilement et rarement." It is well known that this theory of a smaller sister planet has been lately revived by M. Houzeau; but, as is pointed out by Prof. C. A. Young in his recent interesting pamphlet, 'Ten Years' Progress in Astronomy,' it is "certainly untenable; a planet large enough to show phases, as the hypothetical satellite is said to have done, in the feeble telescopes with which many of the observations were made one hundred years ago or more, would be easily visible to the *naked eye even*. There can be little doubt that all the Venus satellites so far observed are simply *ghosts* due to reflections between the lenses of the telescope, or between the cornea of the eye and the eye lens."

Yours faithfully,

Blackheath, 1886, Nov. 2. W. T. Lynn.

NOTES.

Extraordinary Canard.—A paragraph to the following effect has been going the round of the papers during the past months:—"A report is current that the Astronomer Royal meditates retiring on a full pension at the end of the present year, and that the vacant post will be offered to Mr. Norman Lockyer, on account of the services he rendered in connection with the recent eclipse expedition." The report is based upon "*Truth*," but not upon fact. It may be, however, as a correspondent suggests, that our contemporary has not yet heard of Sir G. B. Airy's retirement, and considers it as yet a thing of the future.

The Argentine General Catalogue*.—It will be remembered that some two years ago Dr. Gould published his Zone-Catalogue, deduced from the Cordoba meridian observations made during the years 1872 to 1883, giving the places of more than 73,000 stars ('Observatory,' vol. viii. pp. 18–20). The work now before us is supplementary to the Zone-Catalogue, and contains the places of those stars whose positions were more rigorously determined during the progress of the above-mentioned observations. Dr. Gould considers that in the preparation of this General Catalogue most of the southern stars brighter than 8½ mag. must have been observed, and that the deficiencies in this respect should chiefly be found north of the parallel of 23°, at which the zones begin. But inasmuch as the new 'Durchmusterung' of Prof. Schönfeld comprises all the southern stars within this region, while accurate determinations of the brighter ones will have been made in the Paris re-observation of Lalande's stars, these omissions will be of comparatively small importance. In no case has proper motion been taken into account in forming the mean places, the Catalogue simply giving the results of observation, showing in every instance the position corresponding to a given date. It is also to be remarked that the Catalogue is arranged in such a form as to exhibit the mean places of the stars deduced from each year's observation reduced to the mean equinox of 1875·0. Those astronomers who desire to use the concluded mean result from all the observations of each star must go through the necessary calculations themselves—a labour which will, we fear, deter many from making as extensive a use of Dr. Gould's great work as they otherwise would. The stars' positions are followed by columns giving the annual precessions, secular variations, number of observations, and references to other catalogues. The mean date of observation in each year is also given. The total number of stars whose places are given in this Catalogue is 32,448.

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* Resultados del Observatorio Nacional Argentino. Tomo décimo cuarto.

THE DIURNAL NUTATION OF THE EARTH'S AXIS.—Some three years ago M. Folie submitted to l'Académie des Sciences, Paris, a theory of diurnal nutation of the Earth's axis. This paper was not printed in the 'Comptes Reudus,' and we are thus ignorant of his formulæ. In the 'Comptes Rendus' for December 13, he gives practical illustrations of results obtained by adopting his theory. So far as we can gather, his method is to obtain from a series of observations of a star a certain constant of diurnal nutation, then, by substituting in his formulæ this value, he obtains a correction to each observation. Here, for instance, is his result for Polaris from a series of observations at Pulkowa:—

	R.A., Epoch 1865.	Corrected R.A.
	h m s	s
1862, April 15........	1 9 40·78	38·71
April 23........	37·48	37·82
May 16........	39·43	38·93
May 31........	40·07	38·83
1869, April 2........	37·46	38·61
April 5........	39·34	38·24
April 26........	37·76	38·51
July 1........	37·39	38·06
Dec. 12........	39·29	38·27

It cannot be denied that these corrected R.A.'s are very alluring; but is it not working somewhat in a circle to obtain a constant from a certain set of observations, and then apply it to correct those same observations? We should like to see this theory applied to an independent series, using a constant of 0″·2, which is about the mean of all M. Folie's results.

STELLAR PHOTOGRAPHY AT HARVARD COLLEGE.—Prof. Pickering has recently presented to the American Academy the results of an investigation in stellar photography which has been conducted at the Harvard College Observatory with the aid of an appropriation from the Bache Fund. Prof. Pickering commences with a rapid review of the history of stellar photography, from its commencement in 1850, when Mr. J. A. Whipple obtained a daguerreotype of *Vega* at Harvard College Observatory. The enterprise was taken up again, after the introduction of the collodion process had supplied photographers with more sensitive and manageable plates in 1857, and the experiments then made by Prof. G. P. Bond were highly suggestive of the value of the aid which photography could render to astronomy. In 1882 a great variety of experiments were made, many of which were described at a meeting of the Royal Astronomical Society by Prof. Pickering during his visit to this country in 1884 ('Observatory,' Vol. vii. p. 199); and a second series was undertaken in March 1885, with results justifying their repetition on a larger scale. A photographic telescope was therefore constructed with a Voigtländer lens of 8 inches aperture and 45 inches focus, the focal length being selected so that the scale of the photographs should correspond as nearly as possible to that of the maps of the 'Durchmusterung.' In the mounting of the telescope neither the German nor English form of equatoreal has been adopted, but a form which recalls that employed by Mr. Lassell for his reflectors. The driving-screw in R.A. is driven by clockwork controlled by a Bond spring-governor, the latter being controlled electrically by a standard clock. With this combination a practically perfect motion of the instrument is secured; but for many purposes Prof. Pickering prefers not to use his clock, but to fix the telescope and allow the image of the star to form a trail on the sensitive plate. He has thus secured trail photographs of 117 stars within 1° of the pole, one of them no brighter than the 14th magnitude; indeed he regards the method of obtaining trails of stars as susceptible of yielding very valuable results. He found, for example, that the average deviation of the measures of the brightness of the above-mentioned stars on different photographs was less than a tenth of a magnitude. Trails of the Pleiades gave results of similar accuracy, and the work of surveying the entire heavens north of −30° Decl. in the same way is now far advanced. By photographing on the same plate polar stars near their upper and lower culminations material has been accumulated for determining the atmospheric absorption on each night of observation. A study has also been made of the application of photography to the transit-instrument, from which it appears that the mean deviation in the determination of the position of a star is about one half for the photographic method what it is for eye-observation. Prof. Pickering has also employed photography for the examination of stellar spectra, and by placing a large prism in front of the object-glass has succeeded in obtaining by a fire-minutes' exposure the spectra of all stars brighter than the 6th magnitude in a region 10° square. With an exposure of an hour the spectra of stars no brighter than the 9th magnitude are shown. The region north of − 25° Decl. is being completely surveyed in this manner. Some interesting studies have been made of the Pleiades, the Nebula in Orion, the satellites of Jupiter, and various other bjects. An examination of the spectra of the stars of the Pleiades hows that, with few exceptions, all are of precisely the same type, a act which renders yet more probable the notion that the members of the group have an intimate physical connection. The exceptional pectra possibly belong to stars that are far removed from the roup, either nearer to us or more remote from us, and some may rove to be suitable objects for observations for parallax. The gion of the sky embracing Mr. Gore's Nova Orionis was photo-aphed on Nov. 9, 1885; but no trace of the star can be perceived the plate, and the star was evidently much fainter then than the time of its discovery five weeks later. Prof. Pickering also scusses the theoretical connection of the brightness of the star, e dimensions of the telescope, and the length of exposure, and ncludes that probably the limiting amount of light needed to press the sensitive plate is proportional to the aperture divided the square root of the focal length. He likewise inquires into e effect of errors of adjustment in the position of the instrument pon the shape of star-trails.

SUN-SPOT OBSERVATIONS AT KALOCSA.—A summary of the results f the sun-spot observations at Kalocsa up to the end of 1885 has cently been published by Prof. Hüninger in the 'Astronomische achrichten,' No. 2762. Prof. Hüninger draws attention to the redominence in number of the spots in the southern hemisphere ver those in the northern. This peculiarity has been especially marked since the commencement of 1883. The same superiority f the southern hemisphere is shown if, instead of giving the umber of spots as in the Kalocsa observations, their areas be taken s in the Greenwich observations.

	Kalocsa (Relative Numbers).			Greenwich (Spotted Area).		
	N.	S.	Total.	N.	S.	Total.
1880 ..	9·4	10·2	17·5	257	159	416
1881 ..	24·9	12·6	37·5	500	229	729
1882 ..	23·2	21·3	44·5	443	558	1001
1883 ..	16·3	35·4	51·7	340	815	1155
1884 ..	20·9	28·2	49·1	478	601	1079
1885 ..	15·9	29·8	45·6	283	528	811

It will be remarked that the Greenwich series makes the southern misphere the more spotted in 1882 as well as in the following ears, whilst the Kalocsa observations give a slight advantage to e northern hemisphere for that year. This apparent discrepancy easily explained when it is borne in mind that the Greenwich ries embraces 343 days of observation, but that of Kalocsa nly 143.

The Kalocsa Observatory.—The first report of this observatory, founded in 1878 by Cardinal Haynald, Archbishop of Kalocsa, has recently been published by Dr. C. Braun, who was its director from 1879 to 1885. The observatory has been erected on the second floor of the Kalocsa gymnasium, and it possesses two domes, the larger sheltering a fine refractor by Merz of 7 inches aperture, the smaller a telescope of 4 inches aperture by Schutz. Besides these equatoreals there is a transit-instrument (aperture 58 millim., focal length 60 centim.) by Cooke, three clocks, a chronograph and chronometer, an altazimuth by Breithaupt (Cassel), and the following spectroscopes:—a small Vogel spectroscope, a small eyepiece spectroscope, a Browning direct-vision instrument, and a large spectroscope for solar work. Besides these there is a Zöllner star-photometer and one of Vogel and Glan's spectro-photometers. The observatory is therefore very completely equipped. The observations carried on at the observatory during Dr. Braun's directorship have been of three principal classes:—(1) the determination of the position of the observatory, (2) the observation of sun-spots, and (3) the observation of the places of comets. The first of these researches is divided into two parts, the determination of the position of the observatory by means of azimuth observations of nine fundamental points, the positions of which were given in the Ordnance Survey, and its determination by astronomical methods. The latitude in the latter investigation rests upon observations in the prime vertical of Capella and α Cygni; the longitude was determined by telegraph with Vienna. The astronomical latitude was found to be $46^\circ\ 31'\ 41''\cdot 99$, the longitude east of Greenwich $1^h\ 15^m\ 54^s\cdot 343$.

The sun-spots were observed by the method of projection, and their observed places converted into heliographic coordinates first by a method of projection and then by calculation, the latter being facilitated by a device designed by Dr. Braun and called by him a trigonometer, which enables the resolution of spherical triangles to be effected almost at sight. The series extends over three years and a half, viz. from May 1880 to the beginning of 1884, and thus supplies a pretty complete record of the late curious and long-continued maximum. The results are summarized for each rotation in short tables, and are also exhibited to the eye in diagrams similar to those of Carrington. At the commencement of each rotation the difference between the longitude of the centre of the Sun's disk as adopted at Greenwich and by Dr. Spoerer is given, a very helpful little item of information. The formula for the Sun's rotation resulting from these observations is given as $865'\cdot 33 - 209'\cdot 86 \sin^2 \lambda$. The downward drift in latitude of the general spotted area is also shown, and attention is called to the curious sort of effort at recovery which is manifested at fairly regular intervals.

Quite one third of the volume is taken up with full descriptions of a number of ingenious additions or improvements to various instruments either actually employed by Dr. Braun at Kalocsa or only projected by him. It is impossible to notice or even to mention all these devices, which show a most fertile invention on the part of their designer. Amongst the number may be noted, however, an arrangement for illuminating the field of the equatoreal, a new form of reversion-spectroscope, a device for photographing the Sun with spots, faculæ, and prominences all displayed at once, and an instrument for eliminating the effect of personal equation in the observation of transits, which in many points anticipated by several years the method independently devised by Prof. Langley.

A CORRECTION FOR GRAVITY IN THE USE OF REFRACTION TABLES.—Prof. Cleveland Abbe has an interesting note on refraction in the 'Astronomische Nachrichten,' No. 2761. He remarks that the reading of the mercurial barometer is not a true index of the pressure that controls the density of the air, until such reading has been corrected for the effect of variations in gravity. This is accomplished by adding to the formula one more factor for gravity, and thus getting

$$R = a \,.\, \tan z \,.\, \left(\frac{1 - 0{\cdot}00259 \cos 2\phi}{1 - 0{\cdot}00259 \cos 2\phi_0} \text{B.T.}\right)^A . \gamma^\lambda,$$

where ϕ is the latitude of the observer, and ϕ_0 the latitude of the station for which the tables are computed.

The exponent A differs little from unity. Prof. Abbe then, assuming that $\phi_0 = 59^\circ\ 46'\ 18''$ (the lat. of Pulkowa) and $57''{\cdot}52$ as the value of a for 0° R. and 29·596 inch at Pulkowa, deduced the following table by using the variations of gravity as given by Broch:—

Latitude.	Gravity factor.		Mean refr. 45° alt. $= 57''{\cdot}52 \times g$.
	log. g.	g.	
0	9·99831	0·99612	57·30
10	9·99838	0·99628	57·31
20	9·99858	0·99674	57·33
30	9·99887	0·99741	57·37
40	9·99924	0·99825	57·42
50	9·99963	0·99915	57·47
60	0·00000	1·00000	57·52
70	0·00030	1·00069	57·56

Showing that the effect of this correction is to reduce all refractions computed for stations nearer the equator than Pulkowa, the amount being $0''{\cdot}2$ at the equator for Z.D. 45°, and increasing with tangent Z.D.

He then suggests that the omission of this correction may serve to partly explain the origin of small systematic differences in declination shown by different catalogues.

Such differences must be caused also by the irregular geographical distribution of pressure and temperature; in fact, the latter may amount to one or two seconds of arc. This cause also introduces appreciable difference in the refraction on the north and south sides of the zenith.

So far as we know, this correction has never been applied; and yet it is strange that it should have been overlooked, as a similar correction is used by meteorologists.

We regret to have to record the death of Prof. Theodor von Oppolzer, which occurred on December 26, at his residence in Vienna. The deceased was in the forty-sixth year of his age.

Minor Planet No. 254 has been named Augusta, No. 255 Oppavia, No. 257 Silesia, No. 260 Huberta, and No. 261 Prymno.

Ephemeris for Comet Finlay (1886 *e*).

By Dr. J. Holetschek*.

For Berlin Midnight.

		R.A.			Dec.				Bright-
1887.		h	m	s	°	′	Log *r*.	Log Δ.	ness.
Jan.	0..	23	49	17	− 1	2·3	0·0565	9·9245	2·3
	4..	0	8	58	+ 1	23·7	0·0670	9·9343	2·1
	8..		28	10	3	45·0	0·0779	9·9461	1·9
	12..	0	46	52	5	59·9	0·0889	9·9598	1·7
	16..	1	5	1	8	7·2	0·1001	9·9752	1·5
	20..		22	36	10	5·9	0·1114	0·9919	1·3
	24..		39	36	11	55·8	0·1227	0·0097	1·1
	28..	1	56	2	13	36·7	0·1339	0·0283	0·98
Feb.	1..	2	11	54	+15	8·7	0·1451	0·0475	0·85

Ephemeris for Comet Barnard (1886 *f*).

By Dr. Aug Svedstrup†.

Comet Barnard has been a bright and beautiful object during the past month, though comparatively few observations of it have appeared in print. It is now moving rapidly southwards, and its brightness is fast diminishing, so that it will soon be lost to English observers. Several observers have called attention to the fact that it has shown two tails, the one several degrees in length, the other, inclined at an angle of about 40° to the principal tail, of about half a degree in length. The spectrum shows the usual three bands.

Ephemeris for Berlin Midnight.

		R.A.			Dec.				Bright-
1887.		h	m	s	°	′	Log *r*.	Log Δ.	ness.
Jan.	0..	19	32	32	+ 4	5·2	9·8652	0·1478	10·5
	5..	19	53	52	+ 1	13·5	9·8935	0·1845	7·8
	10..	20	11	46	− 1	20·1	9·9243	0·2177	5·8

The brightness at the date of discovery is taken as unity.

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* Astron. Nachr. No. 2762. † Ibid. No. 2756.

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Meeting of the Royal Astronomical Society on January 14 81
Meeting of the Liverpool Astronomical Society 94

Articles:—

The Brightness and Masses of Binary Stars. By W. H. S. MONCK, M.A., F.R.A.S. 96
Photography and 42 M. By R. S. JOHNSON, F.R.A.S. 99
Selenographical Notes. By THOMAS GWYN ELGER, F.R.A.S. 100
Meteor Notes. By W. F. DENNING, F.R.A.S. 102

Correspondence:—

The alleged ancient Red Colour of Sirius. By W. T. LYNN, B.A., F.R.A.S.... 104
The present Aspect of the Rings of Saturn. By A. STANLEY WILLIAMS, F.R.A.S. 105
Two fine Meteors. By the Rev. EDWARD BRUCE KIRK 107
Tache rouge de Jupiter—Saturn. By Dr. F. TERBY, F.R.A.S. 107

Notes:—

Theodor von Oppolzer.—The Madras Observatory.—The Washington Observatory.—The Paris Observatory.—The Lick Observatory.—Astronomical Prizes of the Académie des Sciences.—New Variables.—New Variable of the Algol Type.—Hours with a Three-inch Telescope.—Discovery of Comet 1887 *a* (Thome).—Discovery of Comet 1887 *b* (Brooks).—Discovery of Comet 1887 *c* (Barnard).—New Minor Planet 108-112

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CONTENTS OF No. 119.

Meeting of the Royal Astronomical Society on December 10 ....
Meeting of the Liverpool Astronomical Society ....

Articles:—

Account of further Observations of the Lunar Crater Plato in 1882-84. By A. Stanley Williams, F.R.A.S. ....
Meteor Notes. By W. F. Denning, F.R.A.S. ....
Selenographical Notes. By Thomas Gwyn Elger, F.R.A.S. ....

Correspondence:—

Comet Barnard-Hartwig (1886 *f*). By Lieut.-Col. G. L. Tupman, F.R.A.S. .
Mr. Gore's Nova Orionis. By W. H. S. Monck, M.A., F.R.A.S. ....
Red Spot on Jupiter. By A. Stanley Williams, F.R.A.S. ....
Professor Rigaud. By W. T. Lynn, B.A., F.R.A.S. ....
Montaigne's alleged Observation of a Satellite of Venus in 1761. By W. T. Lynn, B.A., F.R.A.S. ....

Notes:—

Extraordinary Canard.—The Argentine General Catalogue.—The Diurnal Nutation of the Earth's Axis.—Stellar Photography at Harvard College.—Sun-spot Observations at Kalocsa.—The Kalocsa Observatory.— Correction for Gravity in the use of Refraction Tables.—Death of Dr. Oppolzer.—Names of Minor Planets ....
Ephemeris for Comet Finlay (1886 *e*). By Dr. J. Holetschek ....
Ephemeris for Comet Barnard (1886 *f*). By Dr. Aug. Svedstrup ....

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 120. FEBRUARY. 1887.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, January 14, 1887.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel, and
Lieut.-Col. G. L. Tupman.

The Minutes of the preceding Meeting were read and confirmed.

Col. Tupman announced that since the last meeting 63 presents had been received. None called for special notice.

The President read the nomination forms of candidates for admission to the Society. One of the candidates, however, was a lady, and

Mr. Ranyard drew the attention of the President to the fact that this proposal was not in the ordinary form, the pronoun "her" being used instead of "him."

The President. Mr. Ranyard has anticipated me. It is my duty to call attention to this nomination because it relates to a woman. There could be no question that at the foundation of the Society the admission of women was not contemplated; but it is doubtful whether, as a matter of law, either our Charter or our Bye-laws exclude them. The Council have had several legal opinions before them, and the majority of the Council are of opinion that they would not be justified in refusing to let this certificate go forward to the general body of Fellows to be dealt with by them as they think fit. It is not so *prima facie* invalid that the Council feel it their duty to keep it from the Fellows. They express no opinion whatever upon the general question. Those who feel that the admission of women is undesirable, or at it is a question which should be first considered at a General

He referred to his communication to the Society in June last. The experiments commenced in May with 61 and 62 Cygni, and were compared with Bessel's results from 1840. The experiments were commenced by taking the distances of four faint stars. The object was to redetermine the parallax by comparing the photographic method with the micrometrical measurements. About 200 photographic plates were taken to determine the distances of the four faint stars. Four plates were generally exposed each night for the purpose. The provisional measure of the parallax of 61 Cygni was obtained as 0″·438, and of 61 and 62 Cygni 0″·441; while Bessel gave 0″·348, Auwers 0″·564, Ball 0″·468, and A. Hall 0″·270. The research would be continued till the end of the cycle. In the paper presented in June he had referred to the liability of the photographic film to be occasionally dislocated, and the desirability of using duplicate plates; but of the 200 plates referred to only 7 had shown any dislocation of the film.

Mr. Sadler. What is the last determination of Prof. Asaph Hall?

Mr. Knobel. The last determination, I believe, is 0″·270.

Capt. Noble. It is very noticeable that Prof. Asaph Hall's stellar parallaxes are very much in defect to those of other observers.

Mr. Knobel. The previous determination of Prof. Hall was 0″·478.

Mr. Ranyard. It is no doubt a matter of very great interest whether the parallax can be determined, or will ever be determined, from photographs. These photographs were taken with the reflector at Oxford, which has a focal length of 10 feet, and I conclude the original negatives were measured, on which a degree is about 2¼ inches. Hence a second would be about 1-1600th of an inch, and the parallex measured would be less than 1-3000th of an inch. Now when you look at photographs, especially photographs on dry plates, with any magnifying-power, you see the star broken up into a number of grains, so that it is not a measurement of two definite dots, but of two groups of dots. It is like measuring the distance between two heaps of shingle, where you have to select the centre of the one group of shingle and the centre of the other group, and to measure the distance between the two centres. Some time ago, when I was endeavouring to make measures of eclipse photographs taken on the old wet process, which certainly break up into finer granulation than the modern dry plates, I thought I could not serviceably use a greater power than 5 or 6. Certainly a power of 20 or 30 would break them up into granules and patches, which would upset one's judgment in determining the centre, and I therefore should doubt whether at present we are at all able to measure to half a second, which would mean less than 1-3000th of an inch. When we get a focal length of 100 feet the problem will probably be changed.

Mr. Common. I should like to observe, in regard to what Mr. Ranyard has said of measuring any star, that in considering the actual size of the image or the actual angular dimensions in the field in certain telescopes, in dealing with photographs and in dealing with the actual stars themselves, the advantage is very much in favour of photographs, and all the disadvantages which apply to the telescope itself apply in a much less degree to the photograph; so that, notwithstanding the exact particulars Mr. Ranyard has got as to size of focal images, any image made with a 10-ft. focal telescope would be subject to more errors than with a corresponding photograph. With the photograph you have the means of measuring at leisure. Any parallax founded upon observations made with the micrometer and a telescope of 10 ft. aperture, visually, cannot be so good as a parallax based on measures taken from photographs of those particular stars.

Mr. Ranyard. Mr. Common missed my point—that you can magnify the image in the telescope by 200 or 300 diameters, but if you attempt to magnify the photographs themselves the lumpiness of the image gives a different effect to the photograph.

Mr. Common. Mr. Ranyard says he applies a certain magnification to the photographic image. He must not forget that the photographic image represents a magnification originally. A 10-ft. focal length gives a certain magnification, and if you get a magnification by the eyepiece, the eyepiece itself does not give the actual magnification; it is only a magnification in conjunction with the focal length. That is the point I wish to establish.

Mr. Ranyard. Still it is very much more than the powers of 20 or 30.

The Astronomer Royal. I should imagine that Mr. Ranyard has not had so much experience in making measures of images in telescopes as on photographs, because there are difficulties from atmospheric tremors which prevent the magnification of the image from being effective and render the measures inaccurate. The image of a star may be dancing about in such a way that having to make a hasty bisection of it you cannot get a very accurate measure. It is to be borne in mind, with regard to the question of parallax, that the most accurate measures that have been made have been made with the heliometer. In that instrument instead of getting the image formed by a perfect object-glass you have it formed by half an object-glass, which introduces a source of error, the image being more or less triangular instead of perfectly round, and thus there is a want of definition about it which interferes very seriously with the measuring of distances. That, think, will be found to be a great defect in the measures of the heliometer. The method is otherwise a very good one. Another defect of heliometer measures is that they require a great deal of labour on the part of the observer to secure a single good measure of distance. The scale has to be read and a variety of things have to be read. In the case of the photograph you want simply a single measure. However, I do not think this is a question to be argued *à priori*, but the real test is the accordance of results. If there is this difficulty of measuring a heap [illegible]le, as stated by Mr. Ranyard, we should expect to find that the results would be very rough indeed, and that individual measures would be very discordant. I have examined Prof. Pritchard's results, and I feel inclined to endorse his statement that his results are more accurate than Bessel's with the heliometer: and as measures on photographs can be made with very much less difficulty and much less labour, it seems to me that these accordant results obtained by the photographic method prove it really the best and most economical for determining the parallax of stars. The great point is to get as accurate determination of the parallax as you can with as little labour as possible.

Mr. Stone asked how long the experiments had been carried on, whether over the whole term of maximum displacement?

Mr. Knobel. About seven months.

Mr. Stone. I should be guided very much by that if the observations have been made over the whole period of displacement, and if the results are then accordant the evidence afforded would be very strong, but if the observations have been divided during the maximum displacement I should not feel so sanguine.

Mr. Knobel. Professor Pritchard states the distance of each of the compensators has been carefully measured. He has taken four comparison stars and measured the components of 61 Cygni from each.

Mr. Stone. The point is whether the observations were made during the period when the displacement is small.

Mr. Knobel. I don't think he states that. He says he commenced May 26, and went on to the end of December 1886.

Mr. Stone. It depends on the disturbances, and whether the observations were taken over the whole of the orbit or not.

Mr. Knobel. He does not give the number of plates used in the earlier part of the year.

Mr. Stone. In a matter of this kind it would be desirable that the observations should be extended over the whole period.

The Astronomer Royal. One point in regard to this method I would call attention to; and that is that stars may be utilized at much greater distances from the star of which the parallax is to be determined by this method than by any other. There is with the other methods a difficulty in determining the relative parallax from stars at any very great distance.

Capt. Noble. You mean the angular distance?

The Astronomer Royal. I mean the distance in seconds of arc. Dr. Gill applied a method of determining the relative parallax from stars at a considerable distance, but it was necessary to get two stars at nearly equal distance on opposite sides. It seems to me with the photographic method we are, to a great extent, independent of all that, and that instead of depending on a few stars, you can with photography make use of a great number of stars, and so get, not merely the relative parallax, but a close approximation to the absolute parallax with a reasonable degree of certainty that it will be nearly the absolute parallax.

Mr. Knobel read a paper on some photographs of the Nebula in Orion, taken by Mr. I. Roberts. The first referred to was taken on the 30th November and enlarged five times. The exposure was 1 hour 7 minutes. It might be compared with the photograph taken by Mr. Common, and much more detail would be seen in this photograph. Some portions came out in fuller detail still under the microscope. Some lines which would be visible were the result of a momentary movement of the instrument. Another photograph taken on the 29th December represented the Nebulæ of the Pleiades with an exposure of 3 hours. On a former occasion he had stated that the principal stars in the Pleiades appeared to be in alignment in one vast nebula, and that inference seemed to be confirmed by this photograph.

Capt. Noble asked for an explanation of the fact that the majority of the stars in the photograph were elongated in the N. preceding or the S. following direction.

Mr. Beck thought the irregular appearance of the stars was very easily accounted for by some slight irregularity in the clock. It was all in one direction.

Mr. Knobel. Mr. Roberts states in his paper that these lines are really due to a momentary disturbance caused by an accidental movement of the instrument. I think that point is satisfactorily explained.

Mr. Common. That Mr. Roberts should have succeeded in obtaining more detail in his photographs of the Orion nebula than I did is quite possible, and followed as a matter of course from a longer exposure. In connection with the photograph of the Pleiades, I may remind you that some seven years ago I described some nebulæ I had discovered, or thought I had discovered, in the Pleiades with the 3-feet reflector. When I brought this to the notice of the Society, I was rather roughly handled by Prof. Tempel, who thought I had not used a sufficiently large telescope. I then showed a rough sketch of the detached nebula near Merope, which has since been photographed by the Bros. Henry, and I have been anxiously waiting to see if any photographs would show a smaller and fainter portion near Alcyone. In two of Mr. Roberts' photographs, taken two months apart, these very points of light are unmistakable. This is more remarkable as bearing out the fact that a smaller telescope will make visible through a photograph that which takes 2½ or 3 times the aperture to render visible to the eye on an ordinary night. That is, to me, the most important point of these photographs. With regard to the direction in which the major axes of these elliptical spots tend, I have nothing to say. The mere fact that a photographic image is round or elliptical is a minor consideration; the great consideration is to get the things there. If you have got them, it becomes an after consideration to get them round. It is a mere mechanical arrangement. I have not the slightest doubt, having heard Mr. Roberts describe his paper here, that he allows a great deal of the exposure to be done by the mere mechanical part of the clock, without any superintending such as I used to give in photographing the Orion nebula. Leaving so much to the clock, without having any human supervision, he must expect to get these elongated stars; and, further, however beautifully an instrument may be adjusted in the true meridian, unless he takes the photograph on the meridian after a very short time he will be troubled by refraction, and if he takes it from an hour on one side to an hour on the other, he will be troubled by refraction in one direction as it is rising and another as it falls, so that it is probable if these photographs were taken with a three hours' exposure—an hour and a half on one side of the meridian and an hour and a half on the other side—that he would get that double-shaped image shown in the photographs, which is not worth considering. Not only does this photograph of Mr. Roberts, taken with the 20-inch reflector, show the nebulæ that I spoke of that I took seven years ago, but it also shows some of the very faint stars that I then, or a year or two after, gave as test-stars for large apertures. I should very much like Mr. Roberts to try his telescope on the delicate double star between β^1 and β^2 Capricorni. There is a chance of his discovering by photography that which with the same telescope he can never hope to see.

The President asked whether Mr. Stone would read his papers on the right ascension of Polaris and observations of the Moon at the Radcliffe Observatory?

Mr. Stone. I have not much to say. Observations of the Moon have been made at the Radcliffe Observatory during the last year, and have been persistently compared with Hansen's tables. I am under the impression that the said tables cannot change *per saltum*, more especially if the observations are carried on over a great number of years. What the figures in the paper show is this:—that if there were any inequalities or not introduced into Hansen's tables from 1754 to 1864, and since that time, they have run away. $15\frac{3}{10}$ seconds is a quantity larger than can be accounted for by any personality or anything of that kind. I do not see that such things can be accounted for by long inequalities; and even if Hansen's tables introduce long inequalities or physical inequalities, the effects will change very slowly and would not lead to the discordances we have now. Since 1864 the observations have increased from -2 to $+15$; but there is still the fact that if the increase has been small, retarded for a short time, we come again to a renewed acceleration. I do not care whether the explanation I give is right or wrong—time will show; but I am perfectly certain that Hansen's tables cannot have changed their errors *per saltum*. They give us places in terms of certain variability, and if that variability is connected with observations in the same way now, as before, there will be no *per saltum* changes. But the facts show that there have been these *per saltum* changes, and I say that nothing would be more likely to retard the advancement of our science than to keep this fact in the background. They must be faced and their explanation found in physical principles; and if the explanation I have given is the wrong one, which is possible, all I can say is that some other explanation of a physical character must be given. As to the idea of making oscillating eclipses of the Moon every few years, and then throw away the table, well, that may be due to a determination of the longitude by the Moon, but it would not advance the science of astronomy.

The President. Have you any remarks to make on the other paper?

Mr. Stone. Simply this, that as far as we have determined our absolute errors for Polaris and the others, we find a remarkable agreement with the places of the other stars furnished by the Astronomer Royal; but that is not quite the case with Polaris. I have thought it worth while to clear our observations and show the discordances, but the difference is not very great. The discordance is worth while pointing out.

The Astronomer Royal. Perhaps I may be allowed to make a remark on this point generally with regard to the discordance between computed and observed places of clock-stars and azimuth-stars. A great deal depends on proper motions. There is a good deal of uncertainty in carrying on proper motions, from the Greenwich Catalogue of 1872 for 14 or 15 years, and the proper motions which we have hitherto adopted are no doubt susceptible of improvement. As soon as we received Auwers' reduction of Bradley's observations with the proper motions we proposed to adopt them; but in the assumed right ascension of clock-stars and polar stars for 1887 these proper motions were not used, and I have now had the places recomputed with Auwers' proper motions. Before finally adopting them I thought it would be prudent to compare them with the Greenwich observations of clock-stars, and I think that in every case, with one exception, Auwers' proper motions represent the Greenwich observed clock-stars very much more closely than those we have used hitherto and which are really dependent upon Bessel's reduction of Bradley's observations. In bringing up places for a long period like 15 years, a very small alteration of proper motions—which is a difficult element to determine—in polar stars will make considerable differences in the places, and we have marked and progressive discordances between the assumed and the computed places of Polaris. At the same time, there are still greater discordances between the computed places as given in the 'Nautical Almanac' and the Greenwich observations, and this may be explained, I think, by the circumstance that the results of the 'Nautical Almanac' places are necessarily brought up for longer periods than those which are issued year by year from Greenwich; so that the matter is capable of tolerably simple explanation—that it depends, I fancy, on the difficulty of determining the proper motions, especially of stars near the pole.

Mr. Stone. I should think the explanation of the Astronomer Royal is likely to be the true one. I have noticed that the later

—which run on a flat rail and have nothing to restrain them except horizontal rollers intended to prevent their running off the rail—have an apparent movement of about an inch (relatively to the edge of the wall-curb) in parts of the circle 8 or 10 feet apart, but I think that is due to the irregularity of the different sections in which the wall-curb are cast. I have not remarked any indication of ellipticity in the dome itself or any yielding of the dome. The apparent lateral movement is due rather to the impossibility of getting brickwork and castings put together in a truly circular form. Its trikes me, as I mentioned to Mr. Common, that that shows the cause of the difficulty which arises in turning many domes where you have a curved wheel working on the top of a narrow rail, or a wheel working in a curved rail, in which case you force the wheel that is connected with the dome to travel on a particular line, and that line is not a perfect circle; so you get a great deal of strain and the dome is twisted out of shape in order to enable the wheel to run. In the case of this dome, I am perfectly satisfied with the ease with which it turns. There we have a cogwheel running in a rack-circle, and it can be turned round at a great rate with one hand when once it is started. We had a great deal more power applied at first than was necessary, and I found the motion might be made much more rapid, so I have taken off the pinion and now it is a direct action. No doubt a smaller dome might be turned easily without any rack by simply turning the wheel itself. The friction of the wheel-plate on the circular rail would be sufficient to turn the dome without any other arrangement; but when you come to a larger size than 30 feet there is no doubt the difficulty increases enormously, and then you want mechanical appliances for turning the dome, which requires, of course, careful consideration. I am only speaking of domes up to 30 feet diameter.

Mr. Lecky. With respect to irregularity in casting, for the Vienna telescope Mr. Grubb made all the wheel-plates by planing the plates along the sides and top of each segment. The planing was done by hand.

The Astronomer Royal. Of course that adds enormously to the expense, and it is an additional expense which it seems to me is quite unnecessary. You can dispense with the perfect truth of the wall-plate if you adopt the system of allowing the dome sufficient play laterally.

Mr. Ranyard. The easiest moving dome I know of is the dome of the great new instrument of Nice, which is 10 feet greater diameter than the dome of the Pantheon at Paris, and it moves so easily that two men can move it round the whole circle in four minutes and one man can easily start it. There is a good deal of play and there are wheels that prevent it going off on one side or another. There is practically no friction. It is only touching on one side.

Col. Tupman. Is it floating?

Mr. Ranyard. The whole dome floats in water.

Col. Tupman. Does it ever freeze?

Mr. Ranyard. I believe it has not at present.

Mr. Common. With regard to what the Astronomer Royal has said, I do not wish to imply that his dome gets 2 inches out. In building a dome, the men who lay the wall-plates have, by the very simplest method in the world, always been able to put the wall-plates within certainly less than $\frac{1}{4}$ of an inch of a true circle. Nothing is easier.

Col. Tupman. If they are correctly cast.

Mr. Common. Well, if they deviate $\frac{1}{4}$ of an inch from the true circle, the whole deviatiation never need be more than a deviation of that particular piece. When they are fixed they are fixed; they do not change.

Mr. Knobel exhibited three photographs of Comet Barnard, taken on December 16, 17, and 26 by Dr. Copeland.

Mr. Knobel read a note by *Mr. Stanley Williams* on a new variable star in *Puppis.*

Mr. Knobel read a paper by the *Rev. S. Johnson* on the occultation of Aldebaran, on January 6, 1887. The star lost its redness as the Moon approached it.

Capt. Noble called attention to the 'Nautical Almanac' for 1890, and to the fact that the tables of Jupiter's satellites therein were those computed 51 years ago. The dimensions of Saturn's rings too were erroneous, and there were other matters incorrect. Looking at the American Nautical Almanac for 1889, he thought there was reason to be ashamed of our national ephemeris.

Mr. Stone said the question of Jupiter's satellites had been heard of for many years. The French had offered large prizes from year to year for the completion of the theory, but without making any improvements. He would not say the 'Nautical Almanac' was perfection, but it was not advisable to keep on changing. As soon as some good tables could be had they should be substituted, and no doubt would be; but that was a far more serious work than Capt. Noble seemed to imagine. Small empirical changes would not be at all satisfactory.

Capt. Noble replied, that though it might be as Mr. Stone said with regard to Jupiter, of the Saturnian system at least more accurate dimensions could readily be obtained from existing measurements.

The matter then dropped.

The following papers were also announced:—

G. M. Seabroke. "Spectroscopic Observations of the Motions of Stars in the Line of Sight, made at the Temple Observatory, Rugby."

W. F. Denning. "Meteors with Curved Paths."

J. E. Gore. "On the Orbit of 14 (i) Orionis (OΣ 98)."

Royal Observatory, Greenwich. "Observations of Comet *f* 1886 (Barnard)."

Capt. W. G. Browne and Capt. W. Randall. "Sextant Observations of Fabry's and Barnard's Comets."

Royal Observatory, Greenwich. "Spectroscopic Results for the Motions of Stars in the Line of Sight, obtained in the year 1886. —No. X."

Royal Observatory, Greenwich. "Observations of Occultations of Stars by the Moon, and of Phenomena of Jupiter's Satellites, made in the year 1886."

The following gentlemen were duly elected Fellows of the Society:—

Rev. W. Birks, Capt. Thos. Exham, Shelley Fisher, Cuthbert Hutchinson, W. E. Jackson, Capt. Thos. Mackenzie, Horace Pearce, F.G.S., F.L.S., James Cruickshank Roger.

The Meeting adjourned at 10^h 0^m P.M.

Liverpool Astronomical Society.

THE fourth meeting of the Session was held on Monday the 10th inst. Mr. C. A. Defieux occupied the chair. In presenting a list of thirty-eight candidates, the Secretary pointed out that eight were from Scotland. He thought this was important, as Scotland had hitherto taken but little interest in astronomy; indeed of the 1000 odd Fellows who formed the Royal and Liverpool Societies, only twenty were from Scotland. He attributed this better feeling to a correspondence which had lately appeared in the Edinburgh papers, where, amongst other reasons given for this apathy, was a supposed reluctance to accept their astronomy from "across the border." This expression, however, only proved how little was understood of the constitution of the L.A.S., for, of the communications before them that night, one was from Glasgow, and others from Vienna, France, and Dublin. If therefore there did exist a "Borderland of Science," it certainly would not be determined geographically. Mr. W. D. H. Deane, M.A., thought the indifference was rather caused by the system of education. Technical Astronomy formed part of the curriculum at the Edinburgh and Glasgow Universities and at most of the public schools, but this was dry work and little calculated to arouse an interest in the science.

The President contributed a list of 33 red stars which had been detected by the late Rev. T. W. Webb, but had not hitherto been published. They had been identified in Argelander, and, in some cases, re-observed with his (Mr. Espin's) 17¼-inch Calver reflector, though ill-health had unfortunately compelled him to relinquish the hope of re-observing them all. The stars had been brought approximately to their places up to 1885, and the list was accompanied by remarks and notes of Mr. Webb, so that the whole formed a valuable appendix to the 'Celestial Objects.'

Comparing occultations past and present, the Rev. S. J. Johnson, F.R.A.S., remarked that the occultation of γ Virginis, which took place on the 19th of last December, was observed under very different circumstances to what would have been the case half a century ago, for it was just 50 years since Smyth observed γ Virginis as a single star. So few conspicuous double stars lay in the Moon's path, that when the occultation of one happened, it was attended with great interest. β Scorpii was occulted in September 1871, but this did not seem to have been observed. The immersion of γ Virginis took place when the Moon was low down, so that it was impossible to see the stars separately, but at the reappearance things were more favourable, though, unfortunately, he just missed the emergence of the companion by turning his head to note the exact time. From an observation in 1756, Mayer found the position-angle =54° 21′, and inferred a revolution in 700 years; but in 1781 Herschel found it =40° 44′, whilst in 1830 it had altered to 30° 20′, so that it seemed pretty certain that the period could not much exceed 180 years. It was from an observation of this occultation that Ferguson endeavoured to prove the Moon devoid of an atmosphere.

Mr. W. H. S. Monck, F.R.A.S., reviewed the different theories as to the origin of meteorites. The one which accounted for their existence by projection from terrestrial volcanoes was open to grave objections, but principally on account of the enormous velocities which had at times been observed. The great detonating fireball of 23 Nov. 1877 had, for example, been estimated by Col. Tupman to have moved with at least parabolic velocity, and many other instances of a like speed had been noted. No such velocity could be imparted by volcanoes; therefore if the theory were defensible, it must be in connection with Mr. Proctor's hypothesis of planetary or even stellar origin.

Mr. S. M. Baird Gemmill had observed a star which he suspected of variability. Its position was *p* the fine orange star which formed a triangle with 119 and 120 Tauri. In October 1884 he had estimated it at 8 mag., but in the following October he had found it quite half a magnitude brighter.

In a note on the recent maxima of U Geminorum, Mr. J. Baxendell, Junr., referred to a former paper on the subject by George Knott, which he thought should form a standard for future estimates. The star was well worthy of careful observation, both on account of the varied phenomena it presented, and from the fact that it seemed to form a kind of connecting link between the so-called new or temporary stars and those of a more regular period.

Monsieur C. M. Gaudibert described the crater and neighbourhood of Condamine (Webb 237) which he had observed on the 6th December, when the libration was very favourable. The air would not permit of a higher power than 100 on his 8½-in. reflector, but he had distinguished several markings which were not included in Neison. There was also a wide opening on the N.W. and a much smaller break on the opposite wall. Besides these two ruptures, the whole ring was very uneven, particularly on the S.W. side, where there were four craters—the smallest on the wall itself.

In a continuation of his papers on Telescopes, Mr. W. F. Denning, F.R.A.S., dealt with the influence of wind on definition. The east wind was rarely favourable, though the rule was far from absolute. They should remember that several distinct currents sometimes prevailed, with the air strata in different degrees of humidity. A mere surface-breeze from the east might therefore underlie an extensive and moist current from the S.W., when the definition would be very fair. Calm nights with a little haze were often the best of all; whilst with sparkling and brilliant stars there was generally wretched definition. In the course of a night the definition would sometimes fluctuate in a most remarkable manner, so that an observer who found it impossible to obtain satisfactory images might an hour or two later have no reason to complain. It frequently happened that a morning following a turbulent night became so fine that it might be included in the 100 hours which had been assigned by Sir W. Herschel as the annual limit.

Mr. W. S. Franks, F.R.A.S., described Saturn as a beginner might expect to view it with a 3-in. telescope, and Mr. T. G. Elger, F.R.A.S., continued his illustrated papers on "the Moon surveyed in common Telescopes."

The meeting concluded with an exhibition of photographs of nebulæ, star-clusters, Saturn and Jupiter, by MM. Henry and Herr von Gothard. An examination of the nebula in Andromeda disclosed the remarkable fact that the 4½-in. stellar camera photographed considerably more detail than the 17-inch refractor of the Brothers Henry, or even the 3 feet telescope of Mr. Common. This was accounted for by the shortness of its focus, which would concentrate the more delicate rays into a smaller compass, although the larger instruments photographed from 6 to 8 times the number of faint stars.

Mr. R. S. Newall, F.R.S., F.R.A.S., was elected on the Council in place of Mr. John Stead, deceased. The meeting adjourned at 9.45 P.M.

The Brightness and Masses of Binary Stars.

THE following relation between the brightness and masses of binary stars has not, I believe, been hitherto published, and it possesses the advantage of being independent of the distance or parallax, respecting which much uncertainty exists. It supposes that the mass of the smaller star of each pair is very small compared with that of the larger. It would not, I think, be difficult to show how the result would be modified if the ratio of the masses of the two stars constituting each pair was known; but there are few, if any, binaries in respect to which we possess this knowledge. A series of careful measurements, however, between each component of the binary system and some neighbouring star or stars might enable us to surmount this difficulty and to present a much more complete theory of the subject than I am in a position to offer at present.

Let I_1 I_2 be the total amount of light which we receive from two pairs of binary stars, and i_1 and i_2 the amounts which we would receive from a pair of stars of equal masses with the binaries respectively placed at the same distances, and of what I may term the standard density and illuminating-power. Then if we put $I_1=k_1\,i_1$ and $I_2=k_2\,i_2$, the brilliancy or illuminating-power of our binaries will be represented by k_1 and k_2, and the ratio $\frac{k_1}{k_2}$ will give their relative brilliancy, which is independent of the standard which we choose to adopt. The object of this paper is to deduce the value of $\frac{k_1}{k_2}$ when the values of I_1 and I_2 are known photometrically, and the orbits of the two binaries have been determined.

Let r_1 r_2 be the radii of stars of standard density and illuminating-power, having the same mass and distance as our respective binaries, and let d_1 d_2 be the distances. Then since the surface of a sphere is proportional to the square of the radius,

$$i_1 \;:\; i_2 \;::\; \frac{r_1^2}{d_1^2} \;:\; \frac{r_2^2}{d_2^2};$$

$$i_1^{\frac{3}{2}} \;:\; i^{\frac{3}{2}} \;::\; \frac{r_1^3}{d_1^3} \;:\; \frac{r_2^3}{d_2^3} \;::\; \frac{m_1}{d_1^3} \;:\; \frac{m_2}{d_1^3}.$$

Where m_1 m_2 are the masses of the respective binaries; for of course the masses of the standard stars will be as the cubes of their radii.

But if P_1, P_2 be the periods of the binaries and a_1, a_2 the angular radii of their orbits, then (treating the mass of the smaller star of each pair as insignificant)

$$m_1 \;:\; m_2 \;::\; \frac{a_1^3 d_1^3}{P_1^2} \;:\; \frac{a_2^3 d_2^3}{P_2^2},$$

or dividing the first and third members of this proportion by d_1^3 and the second and fourth by d_2^3,

$$\frac{m_1}{d_1^3} \;:\; \frac{m_2}{d_2^3} \;::\; \frac{a_1^3}{P_1^2} \;:\; \frac{a_2^3}{P_2^2} \;::\; i_1^{\frac{3}{2}} \;:\; i_2 \text{ as above.}$$

Hence

$$i_1^3 \;:\; i_2^3 \;::\; \frac{a_1^6}{P_1^4} \;:\; \frac{a_2^6}{P_2^4} \text{ or } i_1 \;:\; i_2 \;::\; \frac{a_1^2}{P_1^{\frac{4}{3}}} \;:\; \frac{a_2^2}{P_2^{\frac{4}{3}}};$$

but $I_1=k_1\,i_1$, $I_2=k_2\,i_2$, $\quad\therefore\; \frac{k_1}{k_2}=\frac{I_1}{I_2}\cdot\frac{i_2}{i_1}.$

And finally substituting for $\frac{i_2}{i_1}$ as above we get

$$\frac{k_1}{k_2}=\left(\frac{I_1}{I_2}\right)\cdot\left(\frac{P_1}{P_2}\right)\cdot\left(\frac{a_2}{a_1}\right)^2.$$

This gives the relative brightness (as compared with their masses) of any pair of binary stars whose orbit is known, and whose total light has been measured, provided that the larger star of each pair is of much greater mass than the smaller. The value of $\frac{I_1}{I_2}$ can be easily obtained, in most cases, from the *Harvard Photometry* or *Uranometria Nova Oxoniensis*, which seldom differ considerably in their values. The orbits of the binaries, however, are often open to much more doubt. Still it is impossible not to be struck with the fact that the value of $\frac{k_1}{k_2}$ often differs very widely from unity and indicates a much greater degree of brilliancy (for mass) in one pair of binaries than in another.

In the following table I adopt the well-known binary ξ Ursæ Majoris as my standard, its orbit being perhaps the best defined of any. I did not include α Centauri, because I had no reliable estimate of the total amount of its light. Its brilliancy, however, will probably be found to be not far from the unit of my scale.

Comparative Brilliancy of Binary Stars.

Binary Star.	Brilliancy.	Binary Star.	Brilliancy.
γ Leonis	93·29	ζ Herculis	3·98
Castor	38·24	ζ Cancri	3·03
δ Cygni	35·52	42 Comæ Beren.	2·79
φ Ursæ Majoris	25·32	OΣ 235	2·11
γ Coronæ Borealis	19·34	44 *i* Boötis	1·94
ζ Sagittarii	11·37	η Coronæ Borealis	1·52
β Delphini	9·39	ξ Ursæ Majoris	1·00
ζ Aquarii	8·80	Σ 2173	0·95
Sirius	7·17	γ Coronæ Borealis	0·79
36 Andromedæ	6·14	τ Ophiuchi	0·38
ξ Scorpii	5·84	70 Ophiuchi	0·36
γ Virginis	4·59	η Cassiopeiæ	0·22
ω Leonis	4·42	6 (*p*) Eridani	0·20
14 Orionis	4·38	61 Cygni	0·08

Taking the two extremes in this list while the minor star in each pair probably has a considerable mass, it should be recollected that the requisite corrections will be in the same direction, and perhaps even of proportionate amount, so that the general result as to the relative brilliancy of these stars is not likely to be very materially altered if the orbit of 61 Cygni has been correctly determined. I have taken Peters's period of 782½ years with the angular radius 29″·48.

The brilliancy of the binary star 40 o^2 Eridani moreover will probably prove to be even less than that assigned in the table to 61 Cygni. I may add that my results as regards γ Leonis, Castor, and δ Cygni are confirmed by those of Professor Pickering, arrived at by a different method, an abstract of which appeared in the 'Observatory' for January 1881. The learned Professor is of opinion that if the density of the former star is the same as that of the Sun, its intrinsic brilliancy is 300 times as great. 6 (p) Eridani and 61 Cygni figure at the opposite end of Professor Pickering's list as well as of mine. W. H. S. Monck.

Photography and 42 *M.*

The photograph of the great nebula in Orion, taken by Mr. Isaac Roberts at Maghull Observatory on the 30th Nov. 1886, with his 20-inch reflector of 100 inches focus and an exposure of 67 minutes, exhibits an enormous extension (photographically considered) of this wonderful nebula.

Owing to the long exposure, the stars of the trapezium, and others near the centre, are, in the negative, nearly lost, and are quite so in the prints, through the difficulty of enlarging the faint outlying portions without sacrificing detail in the denser parts.

In a southerly direction it extends to the nebulous star ι Orionis, and to nearly an equal distance on the p side, while on the f side it is not greatly different to Mr. Common's photograph. On the N., 43 M is completely involved in dense nebulosity, and Herschel's *faint* nebula at 33′ N. is delineated as very extensive and brilliant, and exhibits to a marked degree the flocculent appearance characteristic of 42 M, giving the impression that it is in reality joined to the great nebula.

It will be exceedingly instructive to see whether photography can ultimately record all the faint outlying streaks and wisps which have at various times been glimpsed by Lord Rosse, Secchi, W. C. Bond, and others, as the confirmation of these observations would extend this nebula to a length of nearly 6°.

Mr. Roberts is about to try what can be done with a prolonged exposure of 3 hours, as soon as there is any change in the present unfavourable weather.

For the purpose of comparison two well-known photographs may be referred to—one by Prof. H. Draper, taken with an 11-inch reflector, with an exposure of 137 minutes, in 1882, and which is the last plate in Prof. Holden's Monograph; and the photograph taken by Mr. Common, in Jan. 1883, with a 36-inch reflector with 37 minutes exposure.

By plotting out on an equal scale chart the outlines of each of these photographs it is seen that the areas of Prof. Draper's and Messrs. Common and Roberts' measure respectively 46, 100, and 650.

For viewing or photographing *stars* only the illuminating-powers of objectives are (apart from the question of their being catoptric or dioptric) as the squares of their diameters; but when the capacity of forming an image of an *object* having extension is considered, such as a comet or a nebula, the illuminating-power is then inversely as

$$\left(\frac{\text{focus}}{\text{aperture}}\right)^2;$$

so that for the instruments used in the production of the photographs which we have compared the relative light-ratios will be about 58, 346, and 400[*], and the time of exposure necessary to photograph the same area of the nebula will be, with each of these telescopes, in inverse proportion to these numbers, or roughly 172, 29, and 25 respectively.

Mr. Roberts has found as the result of many trials that there is very great variation in the actinic translucency of the atmosphere, even on nights when to the eye the sky is perfectly clear. When this fact is borne in mind, it seems useless to attempt to deduce any conclusions from a comparison of only three photographs.

It would, however, be interesting if the photographic charting of the Milky Way were attempted with an equatoreal camera, the object-glass of which had a diameter bearing a large proportion to its focus and which could be accurately driven by clockwork, so that exposures of about 3 hours could be given.

R. C. JOHNSON.

Selenographical Notes.

STADIUS.—This curious formation, with a border so indefinite that it can only be traced as a whole under very oblique illumination, has scarcely received the attention it deserves from students of the Moon's surface, though both the ring and its vicinity include many details of great interest. The western section of the wall seems to be simply a more or less broken and attenuated extension of the massive mountain-arm branching off from the south-east side of Eratosthenes, and consists of at least two ill-defined segments which, gradually diminishing in breadth and altitude, ultimately degenerate into an inconspicuous ridge on the south side of the ring. If this low irregular boundary is examined when the morning terminator falls a little east of Stadius, a good view may be obtained of a very suggestive and interesting feature in connection with it. It will be seen to be flanked on the east (the side facing the interior) by a wide bank, which gradually slopes down to the floor of the ring-plain. This glacis is pitted with innumerable small craters, and is in one place partly traversed by a short rill, which runs in a south-westerly direction on to the surface of the neighbouring Mare. On 4th December, 1886, $5^h 30^m$ to $6^h 30^m$, a favourable opportunity was afforded for scrutinizing the interior at lunar sunrise, the east longitude of the morning terminator being about 14°. During the time of observation the broad shadow of the great mountain-arm from Eratosthenes obscured all the details of the northern portions of Stadius except part of the rim of the crater B, which stood out amid the darkness. Two prominent spires of shade, due to elevations on the western wall, extended, at 6^h, about one-third the distance across the floor, the loftier pertaining to a peak 700 feet in height, according to Mädler the highest part of the ring. The interior at this stage of illumination is seen to be traversed by two parallel rows of low hills or ridges, the more easterly roughly bisecting the ring in a meridional direction, and projecting a band of shadow with a very jagged outline nearly up to the foot of the eastern border. With the solitary exception of a large crater on the south wall, no other objects of this type could be detected, probably on account of the confusing effect produced by the shadows of the countless little asperities with which the floor is evidently covered. In Lohrmann's drawing of Stadius these ridges are well shown, though, save two or three craterlets, he shows nothing else in the interior. Beer and Mädler omit the ridges and represent seven craters. Schmidt likewise shows no ridges, and draws only about 17 craters, yet in the explanatory text accompanying his great chart, he states that on 4th March, 1849, he counted 50 craters in Stadius, presumably with the heliometer attached to the Bonn observatory. It is possible that in this number he included the large craters on the walls and those just beyond their limits. Stadius has for some time past been specially studied by the lunar section of the "Liverpool Astronomical Society," and more than 30 distinct crater-cones and crater-pits have been seen on the floor alone. The position of some of these objects needs verification; but there can be no doubt that this number is considerably below what might be detected with a moderately large aperture under the best conditions. Schmidt draws the formation somewhat in the form of a horseshoe, open to the north, flanked on the east by the well-known crater-row near Copernicus, and on the west by the mountain-arm from Eratosthenes. He ignores the insignificant but noteworthy barrier which connects the east and west walls on the north and completes the ring. This object is best seen when the east longitude of the morning terminator is about 16°. It is then found to consist of two sections—that on the west being marked by a band of shadow which seems to point rather to the existence of a sudden drop in the surface from the outside region to the interior than to an actual wall, while the eastern section is faintly distinguished by an extremely narrow ridge fringed by a barely appreciable strip of shade. It is immediately north of the first-mentioned portion of this ghostly border that we find the large bright crater B surrounded by a cluster of 8 or 9 minute craters, many of which, together with B, may be identified under a solar altitude of at least 40°. There is a brilliant oval crater on a lofty peak of the Eratosthenes mountain-arm near its southern end, which was first noted by me on December 15, 1885. Though obvious enough, it does not appear to be recorded. There is a second crater a little to the west of it on the plain below.

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[*] Not being able to find from any description of Prof. Draper's telescope the focal length of its object-glass, it has, for the purpose of these calculations, been assumed to be 12 feet. That of Mr. Common's telescope also is not stated in the description in Memoirs R.A.S. vol. 46, but from a measure of his drawing it appears to be about 196 inches.

Kempston, Beds., 1887, Jan. 18. THOMAS GWYN ELGER.

Meteor Notes.

The nights during the last half of Dec. 1886 were unusually clear, though we had frequent storms of rain, hail, and snow, accompanied with severe frosts. I obtained observations on the 15th, 18th, 20th, 22nd, 24th, 25th, 28th, and 29th. In the aggregate 194 meteors were recorded in 34 hours' watching on the 8 nights. Meteors were decidedly rare, and the number exhibited a great falling off when compared with the results of the preceding month. The totals for the whole of each of these months were :—

1886, November: 214 meteors observed during 23¼ hours.
December: 228 meteors " " 37¼ "

Immediately after the Earth emerges from the rich stream of Geminids, meteors, generally, become rare, and it is not until the middle of July that a considerable and sustained increase sets in.

The best shower detected here between Dec. 15–29, 1886, was from 194° +67°, near χ Draconis, from which I saw 17 meteors, including a fireball = ♀, on Dec. 18 11^h 14^m. The agreement of this prominent shower with the radiant of Pons's Comet of 1812 would have been very suggestive of identity had it occurred a fortnight earlier.

I observed about 20 other radiant-points, giving between 5 and 10 meteors each, and have selected the following as the most certainly established :—

Slow meteors.		Swift meteors.		Very swift meteors.	
47°	+65°	125°	+39°	134°	+ 8°
77	+32	129	+19	177	+49
80	+24	133	+43	184	+39
98	+31	231	+52	194	+33
115	+32	248	+70	218	+36

By combining my recent observations with those obtained here in preceding years, I have deduced a number of well-defined showers only visible in the morning hours at the end of November or in December :—

Dec. 12–21 ..	165°	− 6°	Dec. 12–29........	207°	+18°
Nov.–Dec. ..	167	+ 4	Dec. 12–21........	211	+ 9
Nov.–Dec. ..	175	+ 9	Nov. 28–Dec. 13 ..	220	+14
Dec. 12–21 ..	185	−13	Nov. 20–Dec. 13 ..	221	+43
Dec. 21–28 ..	201	+ 4	Nov. 28–Dec. 13 ..	230	+34

The position in Virgo at 201° $+4^c$ accords singularly well with the computed radiant of Comet 1846 VII., Dec. 12–17, 200°·5 +4°·5 ; and the shower of Cancrids at 129° + 19°, in the first table, falls extremely near the radiant of the great Comet of 1680, Dec. 27, 133° +22°. Both these comets at their descending nodes passed near the Earth, and a physical association may quite possibly exist between them and the meteor-streams alluded to.

The first few nights of Jan. 1887 were overcast, and nothing could be seen of the Quadrantids; but on Dec. 28, 1886, I saw two meteors, and on Dec. 29, three others, from this shower, and the paths indicated the radiant in the usual position. This system is understood to be very short-lived, but I have observed meteors from it on Dec. 28 and Jan. 4 (in 1877), so that it endures at least 7 days.

Bright meteor.—A beautiful slow-moving meteor, =Sirius, was seen at Sidmouth on Dec. 28, "within a minute or two of half-past 10," and is described as "starting from between Pollux and the star-cluster in Cancer, and travelling in the direction of Regulus, going out before it reached that star." This meteor was observed at Bristol at $10^{h}\ 28^{m}$, Dec. 28, traversing an arc of 19° from 95° +9½° to 106½° −6°. The radiant was attributed at 77° +32°, from whence I had noticed a few other slow meteors falling on preceding nights.

Comparing the observations at the two places, it appears the meteor first became visible at an elevation of some 97 statute miles over a point in the English Channel in lat. 50° 12′ N., long. 1° 25′ W., or 28 miles off the Isle of Wight. Travelling to N., with a very slight inclination W., it became extinct in lat. 50° 30′ N., long. 1° 27′ W., when at a height of 39 miles, and situated above a point 10 miles S.W. of Niton, in the Isle of Wight. The extent of its visible flight was 62 miles, and its direction of motion was inclined 69° to the Earth's surface. The Earth-point is indicated slightly W. of Yarmouth, Isle of Wight, and near Lymington on the S. coast, where it would have fallen could it have withstood disruption along the 42 miles which separated it from this place.

The estimated duration was 3 sec., so that the meteor had a real velocity of more than 20 miles per second, which exceeds that derived from a parabolic orbit, though the difference may quite possibly have its origin in observational errors.

The meteor belonged to a radiant at 77° +30°, near β Tauri, from a projection of the two paths, but from observations of other slow meteors at the same epoch I make the radiant 2° N. of this point. This shower was, however, extremely feeble at the end of December 1886, for in 34 hours of observation (during 18 of which the region of Taurus and Auriga was well in view) only about 5 meteors emanated from it. It could not have furnished more than one meteor for every 6 hours of observation, but I regard the radiant as most certainly established. It has not been hitherto observed at the end of the year, though in the autumnal months many showers succeed each other from this particular region of the sky. Some details of these are given in the 'Monthly Notices,' Vol. xlv. pp. 105 and 109, and 'Nature,' Vol. xxxi. p. 465.

Fireball of 1886, *Nov.* 17.—This brilliant visitor, to which reference was made in our "Notes" of Dec. and Jan. ('Observatory,'

ix. pp. 393–4 and x. pp. 66–7), was also observed at Stonyhurst College, near Whalley, where "it appeared to be several times as bright as Venus. In colour it was violet and of a distinct pear shape. The part of its path observed, as far as could be judged from the stars seen through detached clouds, was from near ι Ceti to the small stars above Fomalhaut about 88 Aquarii. Its path was slightly curved. So brightly did it shine that attention was first called to it by the illumination of the sky, although seen from a room in which the gas was lighted" ('Nature,' Dec. 2, 1886, p. 111). Comparing this observation with the real path described in the 'Observatory,' Jan. pp. 66–7, it will be found that the earth-point W. of Church Stretton and the radiant S.E. of α Arietis are well confirmed. But it is evident that, owing to the clouds which prevailed at Stonyhurst, only the latter part of the fireball's flight was observed there. The point of extinction, near 88 Aquarii, as approximately assigned by the Stonyhurst observers, gives the height as 24 miles over Kidderminster, which is in fair accordance with the result for end point stated in our last month's notes; but the agreement would be more precise if we assume that the extreme end of the path was not seen at Stonyhurst owing to the clouds.

Bristol, 1887, Jan. 7. W. F. DENNING.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The alleged ancient Red Colour of Sirius.

GENTLEMEN,—

It is well known that it is generally supposed that the colour of Sirius has undergone a change since the most ancient recorded observations, from being red to the white which we now see it. Thus in the late Rev. T. W. Webb's 'Celestial Objects for Common Telescopes' (4th Edition, p. 259), he says:—"Its colour has probably changed. Seneca called it redder than Mars; Ptolemy classed it with the ruddy Antares. I now see it of an intense white, with a sapphire tinge, an occasional, probably atmospheric, flash of red."

It seems to me to be worth while therefore to call attention to the fact (which has apparently been much overlooked) that Prof. Schjellerup, in his admirably annotated translation of Sûfi's description of the fixed stars, has shown that the belief respecting the early redness of the light of Sirius, at any rate as respects Ptolemy's ascription of that colour to it, is probably founded on mistake. Sûfi's name in full was Abd-al-rahman Bin Umar Bin Muhammad Bin Sahl Abu'l-husaïn al-Sûfi al Razi; the surname Sûfi probably indicating that he was attached to the sect of the Sûfis, and that of Razi that he was of the town of Raï, in Persia, a little to the east of Teheran. He was born in the year 291 of the Hegira, corresponding to 903 of our era. "He was," says Schjellerup, "un savant du premier ordre, un esprit supérieur, qui véçut à la cour de Schiraz et à Bagdad, jouissant de la plus haute réputation et en grande faveur auprès de Ad-had al-Davlat, de la dynastie des Buïdes, qui alors régnait en Perse." His description of the fixed stars is founded on that of Ptolemy, but is by no means a simple translation of that in the Almagest. "Toutes les étoiles en ont été cherchées et recherchées au ciel dans leur propre position, comme l'indique le Catalogue de Ptolémée, et chacune a réellement été soumise à un examen attentif." Now in speaking of Sirius, Sûfi gives no translation of the Greek designation *ὑπόκιῤῥος*, applied to it in our editions of Ptolemy. In addition to this we have the fact that Al-Battani (commonly called in European books Albatenius or Albategnius) says that Ptolemy speaks of *five* red stars, whilst in our copies of the Almagest *six* are so called—Arcturus, Aldebaran, Pollux, Antares, Betelgeuse, and Sirius. Now with regard to the last, the star in question, the expression is in the Greek somewhat peculiar. It is this :—*Ὁ ἐν τῷ στόματι λαμπρότατος καλούμενος κύων καὶ ὑπόκιῤῥος.* The conjecture of Halma, one of the editors of the 'Almagest,' seems (we may agree with Prof. Schjellerup in thinking) not improbable, that the last word in this description is an early error of transcription for *σείριος*, which might be called a *name* for the star, whilst *ὑπόκιῤῥος* certainly was *not*. It is quite true that Cicero, Horace, and Seneca speak of it as being red ; but in ancient, as in modern, times it was not very uncommon in copying to copy errors. Cicero moreover professes to be translating Aratus, who does not call Sirius red, but *ποίκιλος*, so that the rendering "rutilo cum lumine" is very free, and not a correct rendering of the original. Horace is scarcely an astronomical authority ; and when Seneca says "Acrior sit Caniculæ rubor," he may be speaking of certain occasions when atmospheric conditions would certainly give Sirius a reddish appearance. It was, however, long ago suggested, in the Delphin Edition of Seneca, that the word used by that philosopher in the place ('Questiones Naturales,' lib. i. ch. 1, § 6) was not "rubor" (as it is in our copies) but "fulgor," which certainly reads much more naturally. No other ancient author attributes a red colour to the star, and on the whole the probability seems to be against any change in that respect having taken place.

Yours faithfully,
W. T. Lynn.

Blackheath, 1887, Jan. 4.

The present Aspect of the Rings of Saturn.

Gentlemen,—

The actual appearance presented by the outer ring of Saturn, as regards divisions or other markings visible in or upon it, has during the last few years given rise to much question and discussion, without, however, any definite decision upon the subject being arrived at. Many observers of note have denied the existence or visibility of the division, or marking, known as Encke's, whilst many others of equal eminence have affirmed its continued visibility. In 1884 MM. Henry detected a brilliant zone in this ring immediately contiguous to the Cassini division, and which they considered gave rise to the appearance of Encke's division by contrast. This bright zone has suffered the same fate as the last-mentioned division, its existence having been affirmed by some and denied by others, and that almost at the same time. In this case, however, there is more chance of the matter being put at rest, since it is said to be shown upon a photograph of the planet taken by MM. Henry. In December 1885, Mr. Denning describes a narrow bright zone as being visible near the middle of the ring instead of just adjacent to the Cassini division. The subject of the markings visible upon the outer ring thus remains at the present moment involved in doubt; the ring-system is already closing up, and before long the opportunity of solving it will be lost. During the past month I have devoted a considerable amount of attention to Saturn, and the following are the principal results relating to this ring derived from observations made on ten nights, on several of which the conditions of seeing were more or less good.

In the first place, it may be stated that on every occasion, excepting one or two cases of bad definition, there was little real difficulty experienced in seeing the bright zone, which was likewise always immediately contiguous to the principal division in the rings. But there were differences, apparent or real, in the plainness of this zone, and also in its width from time to time. For instance, on December 25th last the breadth of the bright zone was carefully estimated as being equal in width to the Cassini division; whilst on December 31st it was no more than half the width of this division. It also seemed plainer sometimes at one of the *ansæ* than at the other. With the utmost attention, however, no other markings could ever be seen with certainty, although at times there were suspicions of a feeble dark line about halfway between the outer edge of the ring and the outer edge of the bright zone. Once or twice, too, the middle part of the ring was thought to be broadly though feebly shaded. What seemed to be quite certain, however, was the impossibility of any appearance like that attributed to the marking known as Encke's division being caused by contrast with the bright zone, at any rate in the present condition of this feature, which is too narrow and too far removed from the place generally given to that division to produce any such effect, except possibly under very disturbed atmospherical conditions, when of course no one would think of making delicate investigations. The Encke division, or marking, therefore, would seem not to be caused by contrast with this bright zone, but to have had, when seen, a real objective existence. The bright zone did not appear always equally defined, and at all times it was rather liable to be masked by the vastly superior brilliancy of the exterior portion of the inner bright ring unless particularly looked for; a peculiarity which may account for the inability of some observers to see the object at all. It should be remarked that this bright zone is not necessarily by any means a recent feature. A greater brightness at the inner edge of the ring was noticed by Coolidge, Dawes, and Lassell ('Celestial Objects,' p. 177).

The dusky "crape-ring" has lately been irregular in brightness. On Dec. 31st at $11^h 30^m$ it was noted as being distinctly plainer in the preceding than in the following *ansa*, whilst at $14^h 25^m$ on the same night it was about equally plain on either side. On Jan. 1st at $11^h 40^m$ it was *considerably* plainer in the preceding than in the following *ansa*, and again at $15^h 10^m$ it was about equally plain on either side. It would seem probable, therefore, that the general mass of this ring rotates in a period not very distantly removed from 12 hours.

These observations were all made with a 6½-inch Calver reflector of good quality, a power of rather over 300 being preferred whenever the weather permitted.

Yours faithfully,
A. Stanley Williams.

West Brighton,
1887, Jan. 20.

Two fine Meteors.

Gentlemen,—

Last night, at about 9.10 p.m., I observed two fine meteors. The first was reddish and > Jupiter. Its path extended from ξ and ο Ceti to ζ Ceti. It had a brilliant reddish train with many sparks. Time of traversing its path 1·5 sec. The other's path was from about 2° east of ξ and ο Ceti, to about 5° east of ζ, its velocity rather less, brightness = 1 mag., and colour bluish. It might be a second or two later in appearing than the first. It was bright moonlight at the time.

Yours faithfully,
Edward Bruce Kirk.

Barrhead, Scotland,
1887, Jan. 13.

Tache rouge de Jupiter—Saturn.

Messieurs,—

Je ne sais si le fait dont j'ai l'honneur de vous entretenir a déjà été signalé, mais il me semble qu'il présente un grand intérêt: dans l'ouvrage de M. Liais, l'*Espace Céleste*, p. 463, on trouve deux dessins de Jupiter faits en 1856, par Chacornac. A-t-on déjà signalé que ces deux dessins sont tout à fait analogues à ceux que l'on a faits ces dernières années et qu'on y remarque *une bande 3 I avec dépression* tout à fait identique à la dépression qui accompagne aujourd'hui la tache rouge? La tache rouge seule n'y figure pas, mais *la place en est parfaitement indiquée*, et, si l'attention de Chacornac avait été attirée d'avance sur ce point, peut-être en aurait-il aperçu *les rudiments*. Je signale ce fait curieux à l'attention de M. Marth *.

J'aurai le plaisir de vous entretenir bientôt plus longuement de mes observations de Saturne. Cette fois j'ai pu juger définitivement et directement l'incomparable définition de mon objectif de Grubb qui montre nettement cette planète avec les grossissements de 450 et de 650 fois ; observant avec M. Tennstedt, d'Enghien, j'ai vu la *division d'Encke*, *l'anneau obscur* et la *division de Struve séparant les anneaux C et B* et d'autres détails dont j'aurai l'honneur de vous entretenir. J'appelle, en attendant, l'attention des lecteurs de l'*Observatory* sur la division de Struve, si visible actuellement pour moi dans mon huit pouces. Quant aux satellites, je vois constamment Titan, Japet, Rhéa, Téthys et Dione †. Je vois sans difficultés la 5^e et la 6^e étoile du trapèze de la nébuleuse d'Orion.

Je vous prie, Messieurs, de bien vouloir agréer l'assurance de mes sentiments les plus distingués. Votre bien dévoué,

Louvain, le 28 décembre, 1886. Dr. F. Terby.

NOTES.

Theodor von Oppolzer.—Theodor von Oppolzer, whose death occurred on Dec. 26, 1886, was the son of the celebrated pathologist Dr. Johann v. Oppolzer. He was born at Prague, on Oct. 26, 1841. In accordance with the wish of his father, young Oppolzer studied for the medical profession, and for this purpose he entered the University of Vienna, where he soon showed great aptitude for the exact sciences, and was more especially attracted to Astronomy. In 1864 he took his full degree of Doctor of Medicine, and entered as teacher at the Vienna High School, where since 1875 he has held a Professorship. His first efforts in the scientific world were some excellent computations of orbits of small planets and comets, in which department he developed especial ability. It is indeed by his classical work "Lehrbuche der Bahnestimmung der Planeten und Cometen" that he is best known. Since 1873 he has been occupied in the Survey of Austria in connection with the "Europäische Gradmessung." In the midst of his various duties he still found time to complete his "Kanon der Finsternisse," a chronological research containing the elements of all eclipses of the Sun and Moon for a period of 3500 years from 1500 B.C. to A.D. 2000. In his last years he gave much attention to the Theory of Perturbations, and was at the time of his death engaged on the Lunar Theory. Oppolzer married in 1865, and has had six children. His death occurred suddenly after a short illness.

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* Nous ferons observer toutefois que, si ces deux dessins sont renversés, comme nous le supposons, il faut admettre une erreur dans les heures indiquées pour s'expliquer le sens de la rotation ; les heures ont été interverties.

† Depuis que cette lettre est écrite j'ai pu observer aussi le satellite Encelade.

The Madras Observatory.—From Mr. Pogson's Report for the year 1885 we learn that during the year his attention was chiefly directed to work connected with the publication of the meridian circle observations from 1862 to the present time. At the close of the year under review the formation of the star ledgers and the deduced catalogues of mean position were completed for 1862 and 1863, and partly for 1864, which will form the first of the eight volumes about to be published. The star ledgers for the next three years—1865 to 1867—were also in progress for the second volume. Observing work has been almost entirely suspended until the publication of the past results is accomplished. It is satisfactory to find that serious efforts are at length being made to publish the results of the Madras observations taken during the directorship of the present Government Astronomer.

The Washington Observatory.—The Annual Report of Commander Allan D. Brown, U.S.N., Superintendent of the U. S. Naval Observatory, has been issued under date October 20, 1886. The work with the principal instruments—the great equatoreal, the transit-circle, and the 9·6-inch equatoreal—has been carried on as usual. The great 26-inch equatoreal, in charge of Prof. Hall, has been used in observations of the Satellites, of double Stars, and of Saturn. Observations of stellar parallax have also been made. No deterioration of the object-glass has been noticed since it was repolished ten years ago. The principal drawback is that which will hold for every large telescope, viz., the lack of sufficiently good atmospherical conditions; on the few fine nights enjoyed at Washington, the performance of the instrument is good. The transit-circle has been employed in observations of stars of the American Ephemeris, of the Sun, Moon, and Planets, and such miscellaneous stars as were necessary to complete the data for the proposed transit-circle catalogue. The whole number of observations since the last report has been 5180. It is pointed out that the early completion of the transit-circle catalogue is a matter of the greatest importance, and we note with regret the remark that unless additional help is provided it will be several years before this can be accomplished. The instrument remains in charge of Prof. Eastman. The 9·6-inch equatoreal has been used by Prof. Frisby in the observations of comets, asteroids, and occultations of stars by the Moon. Photographs of the Sun have been taken with the apparatus lately belonging to the Transit of Venus Commission (the "horizontal" photoheliograph) whenever practicable. Prof. Frisby has undertaken the necessary revision of the second edition of Yarnall's Catalogue, preparatory to the issue of a third edition. Up to the present a large number of errors have been discovered, many of which are, however, of but slight importance. It is hoped to have the revision completed during the next year.

THE PARIS OBSERVATORY.—We regret to learn that the scho of astronomy attached to this observatory is to be discontinue this year for financial reasons.

THE LICK OBSERVATORY.—We learn from a San Francisco pap that the crown and flint lenses for the great equatoreal of the L Observatory arrived there safely on Dec. 27. They were found be in fine condition, and were mounted in a cast-iron cell, a packed away in a fireproof vault in the north room, until t mounting should be ready. It is anticipated that the great te scope and the observatory will be handed over to the trustees the Californian University early in the forthcoming autumn.

ASTRONOMICAL PRIZES OF THE ACADÉMIE DES SCIENCES.—M. O Backlund has received the Lalande Prize for his investigations of the motion of Encke's comet; M. Bigourdan the Valz Prize chiefly for his inquiries into the effect of personality in the observation of double stars; and M. Souillart the Damoiseau Prize for the revision of the theory of the Satellites of Jupiter. An encouragement of one thousand francs from the Damoiseau fund has also been decreed to M. Obrecht.

NEW VARIABLES.—Mr. Espin, in Circulars Nos. 12 and 13 of the Liverpool Astronomical Society, has definitely ascertained the variability of the star near θ' Tauri, which he had been led to suspect through his inability to find the star (see 'Observatory,' No. 116, p. 370). Mr. W. H. St. Q. Gage found it about the 9th mag. on Jan. 16, but on Jan. 22 it was barely of the 10th. It is probably a variable of fairly long period, with variation from $9^{m} \pm$ to below 12^{m}. Place for 1885·0: R.A. $4^{h}\ 21^{m}\ 25^{s}$, Decl. $+15^{\circ}\ 50'\cdot 7$.

Mr. S. C. Chandler, Jur., has recently discovered* a new short-period variable in Cygnus. The variation is from 6·3 m. to 7·6 m., and occupies a little over fourteen days, the increase occupying about four days and the decrease ten days. The decrease is not quite regular, there being a halt about the middle of its course. Place of the star, which is Lalande 40083, for 1875·0: R.A. $20^{h}\ 38^{m}\ 30^{s}\cdot 2$; Decl. $+35^{\circ}\ 8'\ 24''\cdot 6$. Provisional elements 1886 Oct. 3·60 G.M.T. $+ 14^{d}\cdot 04$ E.

NEW VARIABLE OF THE ALGOL TYPE.—During the observations of the preceding star Mr. Chandler made a yet more interesting discovery, since one of his comparison stars proved to be a variable of the Algol type. This star (D.M. $+34^{\circ}$ No. 4181; Place for 1887·0 R.A. $20^{h}\ 47^{m}\ 32^{s}\cdot 5$, Decl. $+34^{\circ}\ 13'\ 59''\cdot 5$) varies from 7·1 to 7·9 in a period which is some fraction of $5^{d}\cdot 997$, Mr. Chandler giving* the following approximate elements for it:—1886, Dec. $9^{d}\cdot 458$ G.M.T. $+\left(\frac{5^{d}\cdot 997}{n}\right)$E. His observations show him that † ıer 3 or 5, and a consideration of the other variables ads him to infer that *n* is probably 4, 7, or possibly 8, ; to periods of $1^d\ 11^h\ 59^m$, $20^h\ 34^m$, and $18^h\ 6^m$ re- The reasoning on which this inference is based is as e period of oscillation is about six hours. As the le will show, in the other seven variables of the type, ıe period of the star the higher is the ratio which the ation bears to the entire period. Unless, therefore, n exception to the rule shown by the other members the period cannot be much less than one day, nor so days.

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* Gould's Astron. Journ. No. 148. † Ibid., No. 149.

Star.	Period.	Duration of Oscillation.	Ratio.
	h	h	
chi	20·13	5·0	0·248
....	55·85	12·0	0·214
i	59·82	10·0	0·167
....	68·81	9·15	0·134
æ..........	82·85	9·75	0·118
....	94·87	10·0	0·105
....	227·63	21·5	0·094

consideration enabled Mr. Chandler to correctly fix f U Ophiuchi before it had been determined from ation.

H A THREE-INCH TELESCOPE *.—This little work is, as nforms us, designed to instruct the very beginner in n instrument of the size specified, mounted on a e-stand, and unprovided with any means of finding ıe sky by their coordinates. It appears, on the very well adapted to the carrying out of this design, bably induce many a young student to make himself s far as his instrumental means permit, with some of of the heavens here brought to his notice, and perhaps o study that best of all handbooks for the amateur, stial Objects for Common Telescopes,' to which the us is avowedly an introduction. Capt. Noble's book pters on The Instrument—The Sun—The Moon— —with an additional chapter on Drawing the Planets structive to the beginner) and the Fixed Stars and e like the chapter on the Moon best. In a supposed serving, extending over seven nights, the reader's uccessively drawn to the most remarkable features of capable of being seen in a three-inch telescope. To dent in identifying the different markings he is pre- frontispiece with a map of the Moon, founded on the by Mr. Webb. The larger planets are also carefully far as is necessary for the author's purpose, whilst a uffice for Uranus and Neptune. It should be re-

---

ith a Three-inch Telescope.' By Capt. Wm. Noble. Longmans, *886.*

marked that a speciality of the book is that the illustrations of celestial objects given in it have all been reproduced from sketches made by the author at the eye-end of a three-inch telescope. This is all very well in its way, but we fear that the information afforded will not in every case enable the beginner to identify the stars and nebulæ to which his attention is drawn. The reader is supposed to know no more of the constellations than may be learned from Mr. Proctor's 'The Stars in their Seasons,' and we venture to think that it would take him a long time (for example) fishing "between β Cygni and Delphinus, some 7° south-east of the former star," before he could find the Dumb-bell nebula! In the chapters on the planets the author here and there refers to the "present position" of a particular planet, and gives in a footnote the time at which the corresponding paragraph was written. This apparent anomaly in a book calculated to be of permanent use is explained by the circumstance that it is in great part a reprint of a series of papers written for the pages of 'Knowledge,' in which periodical they originally appeared.

DISCOVERY OF COMET 1887 *a* (THOME).—A fine comet has been discovered in southern latitudes. Up to the present time Mr. Thome, Cordoba, seems to have been the first discoverer, since he observed it on January 18. Its tail was seen at the Melbourne Observatory on January 19, and at the Adelaide Observatory on January 20. The nucleus does not appear to have been observed until January 23, when the following observation was obtained at Melbourne:—

Jan. 23, $8^h\ 0^m$ Melb. M.T.: R.A. $21^h\ 20^m\ 28^s$; Decl. $-44°\ 17'$. Daily motion R.A. $+10^m\ 24^s$; Decl. $51'$ S.

The physical appearance of the comet which, though not a brilliant object, is readily visible to the naked eye in the twilight, strongly recalls that of the great Southern Comet of 1880, the tail being long, narrow, and straight. The tail has been traced for a length of about 30°. The comet is expected to become very brilliant.

DISCOVERY OF COMET 1887 *b* (BROOKS).—On Jan. 22 Mr. W. H. Brooks, Red House Observatory, Phelps, New York, discovered a faint comet. The following position was obtained:—

Jan. 22, $6^h\ 54^m$: R.A. $18^h\ 0^m$; Decl. $+71°$.

It has since been observed at Strassbourg: Jan. 24, $17^h\ 55^m{\cdot}7$, R.A. $18^h\ 29^m\ 4^s$; Decl. $+74°\ 19'$.

DISCOVERY OF COMET 1887 *c* (BARNARD).—A third comet has been discovered by Mr. E. E. Barnard, Nashville, Tennessee. The following observation was obtained at Harvard College:—

Jan. 24, $17^h\ 55^m{\cdot}7$, Camb. M.T.: R.A. $19^h\ 10^m\ 17^s{\cdot}4$; Decl. $+25°\ 57'\ 45''$. Daily motion R.A. $+2^m\ 36^s$; Decl. $-0°\ 35'$. This comet is also faint.

NEW MINOR PLANET.—A new Minor Planet, No. 264, was discovered by Prof. C. H. F. Peters on Dec. 22, at Clinton, U.S.A.

21.] MARCH, 1887. [*Price* 1*s*.

HE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
rsary Meeting of the Royal Astronomical Society on February 11......... 113
g of the Liverpool Astronomical Society 125

es:—

ographical Notes. By THOMAS GWYN ELGER, F.R.A.S. 127
Chromosphere in 1886. By the Rev. S. J. PERRY, F.R.S., F.R.A.S. ... 129
or Notes. By W. F. DENNING, F.R.A.S. 129
Motion of a Comet when Perturbed and Resisted. By W. C. EVANS, M.A., F.R.A.S. 130

spondence:—

further Notes on Binary Stars. By W. H. S. MONCK, M.A., F.R.A.S. . 134
ne—Trapèze d'Orion—Compagnon de Sirius. By Dr. F. TERBY, F.R.A.S. 136
ography and the Determination of Stellar Parallax. By the Rev. Prof. C. PRITCHARD, F.R.S. 137
Argentine General Catalogue. By Lieut.-Col. G. L. TUPMAN, F.R.A.S. . 138
Outer Ring of Saturn: Encke's division? By N. E. GREEN, F.R.A.S.... 139
-circuit Chronometers. By Prof. C. A. YOUNG, Ph.D., For. Assoc. R.A.S. 140

:—

Six Inner Satellites of Saturn.—Total Solar Eclipse of 1886, August 29. —The Temple Observatory.—Observations for Stellar Parallax.—The new Algol-Variable in Cygnus.—Probable new Variable in Andromeda. —Motion of the Lunar Apsides.—Names of Minor Planets.—Editorial Note 140-143
ts and Ephemeris of Comet 1887 *b* (Brooks, Jan. 22). By Dr. H. OPPEN-IM.. 143
ts and Ephemeris of Comet 1887 *c* (Barnard, Jan. 23). By Dr. H. PENHEIM 144
ts and Ephemeris of Comet 1887 *d* (Barnard 2, Feb. 15). By Prof. L. Boss 144

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CONTENTS OF No. 120.

Meeting of the Royal Astronomical Society on January 14 ....
Meeting of the Liverpool Astronomical Society ....

Articles:—

The Brightness and Masses of Binary Stars. By W. H. S. Monck, M.A., F.R.A.S. ....
Photography and 42 M. By R. S. Johnson, F.R.A.S. ....
Selenographical Notes. By Thomas Gwyn Elger, F.R.A.S. 10
Meteor Notes. By W. F. Denning, F.R.A.S. 10

Correspondence:—

The alleged ancient Red Colour of Sirius. By W. T. Lynn, B.A., F.R.A.S. ... 10
The present Aspect of the Rings of Saturn. By A. Stanley Williams, F.R.A.S. 10
Two fine Meteors. By the Rev. Edward Bruce Kirk ....
Tache rouge de Jupiter—Saturn. By Dr. F. Terby, F.R.A.S. 10

Notes:—

Theodor von Oppolzer.—The Madras Observatory.—The Washington Observatory.—The Paris Observatory.—The Lick Observatory.—Astronomical Prizes of the Académie des Sciences.—New Variables.—New Variable of the Algol Type.—Hours with a Three-inch Telescope.—Discovery of Comet 1887 *a* (Thome).—Discovery of Comet 1887 *b* (Brooks).—Discovery of Comet 1887 *c* (Barnard).—New Minor Planet 108-11

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 121. MARCH. 1887.

ANNIVERSARY MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, February 11, 1887.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel, and
Lieut.-Col. G. L. Tupman.

The Minutes of the last Anniversary Meeting were read and confirmed.

General Walker requested permission to withdraw the name of Miss Pogson from nomination as a Fellow of the Society, as it was the wish of her friends that the general question of the eligibility of ladies for membership should first be decided.

Leave was granted for this withdrawal.

Mr. Bryant then presented the Report of the Auditors, with a certificate stating that the Treasurer's account was correct, and that the books and instruments were in safe custody.

Capt. Noble wanted to know how much of the £24,000 voted by the House of Commons for the "Learned Societies" found its way into the treasury of the Royal Astronomical Society.

Mr. Common. If this vote is for the maintenance of buildings occupied by the "Learned Societies" we do derive benefit from it, for our building is kept up, so far as structure and outside are concerned, by the Government.

The Report was then read by the Secretaries. There were notes on the following subjects connected with the progress of astronomy during the past year:—

a. The Velocity of Light.
b. Prof. Schönfeld's Extension of the "Durchmusterung."
c. Determinations of Stellar Parallax.
d. The Harvard Catalogue of 1213 stars for 1875·0.

e. Dr. Kam's Catalogue of 5455 small stars.
f. The Pulkowa Catalogue of 3542 stars for 1855·0.
g. The Second Armagh Catalogue of Stars.
h. The Great Comet, 1882 II. (Cape Observations).
i. The Argentine General Catalogue of Stars.
j. The Total Solar Eclipse of August 28–29, 1886.
k. Professor Asaph Hall's Researches on the orbits of the six Inner Satellites of Saturn.
l. Stellar Photography.
m. The Visual Solar Spectrum in 1884 *.

In addition to these there was a notice of the comets and minor planets discovered during the past year, and reports of work done at several observatories in 1886 were also read. These, with the "balance sheet" and "obituary notices," will be printed in the 'Monthly Notices.'

The President then addressed the Meeting as follows:—

The Council have awarded the Gold Medal to Mr. George William Hill for his researches upon the Lunar Theory; and it now becomes my duty to lay before you the grounds of this award.

The investigations of Mr. Hill's which the Council have had principally in view are contained in the memoir "On the Part of the Motion of the Lunar Perigee which is a Function of the Mean Motions of the Sun and Moon," which was published by him ten years ago at Cambridge, Mass. The merits of Mr. Hill's treatment of this question are such, that, even if this memoir stood by itself as his sole contribution to physical astronomy, the Council would have felt themselves justified in recognizing its value by the highest mark of appreciation which it is in their power to confer. Mr. Hill's object in this memoir is to determine with absolute accuracy the motion of the Moon's perigee, on the assumption that the Sun's orbit has no eccentricity, that the Moon's motion takes place in the plane of the ecliptic, and that the eccentricity of the Moon's orbit is indefinitely small; in other words, to determine an absolutely accurate value of that part of c which depends upon m alone.

It will be remembered that this quantity c, which expresses the mean motion of the Moon's perigee, has played an important part in the early history of the theory of gravitation. Newton proved that the disturbing action of the Sun would produce a continual advance of the Moon's perigee; and he gave a numerical example which has been generally regarded as his calculation of the rate of this advance. The mean monthly progression in this example is 1° 31′ 28″, while the actual progression of the Moon is double this amount. This discrepancy formed one of the chief impediments to the acceptance of the Newtonian system, and an interval of sixty years elapsed before theory and observation were brought into agreement. This was effected by Clairaut, who was on the point of publishing a new hypothesis with respect to the law of gravitation, when it occurred to him to extend the approximation to the third order. He found that the numerical value of the new term was nearly as considerable as that of the term of the second order. The supposed Newtonian value of $1-c$ was $\frac{3}{4}m^2$, and Clairaut's additional term was $\frac{225}{32}m^3$; amounting to about $\frac{7}{10}$ of the previous term. Thus the circumstance which for some time had seemed almost fatal to the Newtonian theory became one of its strongest confirmations.

---

* Most of the above works have already been noticed in our pages, as follows:—

(*a*) No. 109, p. 173.
(*b*) No. 117, p. 399.
(*c*) No. 121, p. 142.
(*e*) No. 113, p. 292.
(*f*) No. 116, p. 359.
(*g*) No. 116, p. 362.
(*h*) No. 113, p. 291.
(*i*) No. 119, p. 74.
(*j*) No. 113, p. 289; No. 114, p. 320; No. 115, p. 338; No. 117, p. 403; No. 121, p. 141.
(*k*) No. 121, p. 140.
(*l*) No. 109, p. 170; No. 110, p. 203; No. 115, p. 321; No. 116, p. 363; No. 119, p. 76.
(*m*) No. 114, p. 316.

The series of which the first two terms were calculated by Newton and Clairaut has been continued by Delaunay as far as the term involving m^9. The progression of the terms is such as we might anticipate from the first two; the coefficients increase rapidly; and, though the smallness of m causes the terms to diminish, their rate of convergence is very slow.

The problem which Mr. Hill set before himself for solution was the exact determination of the numerical value of the quantity represented by this series. The development in powers of m, besides being extremely difficult and laborious to obtain, was from its nature ill adapted for the calculation of c with all the precision that could be desired. Mr. Hill accordingly had recourse to an entirely different method of obtaining the numerical value of this quantity.

Having explained at some length Mr. Hill's method of investigation, the *President* proceeded :—

I am sensible that a presidential address does not in general afford a suitable opportunity for mathematical exposition ; but I have felt that on the present occasion the novelty and intrinsic interest of the mathematical methods employed justify me in the attempt I have made to give a brief sketch of the remarkable investigation by which Mr. Hill has arrived at his numerical value of c. It will be observed that the problem of the determination of this quantity is attacked entirely *de novo*, from first principles, by a peculiar analytical method devised for this especial purpose. The object is to obtain the numerical value of that part of c which depends upon m only ; and this object is attained with a degree of precision that sets the problem at rest for ever.

Although the memoir of Mr. Hill's to which I have so far confined myself was the first in order of publication of his papers on the Lunar Theory, its true chronological place is subsequent to his

"Researches on the Lunar Theory," which appeared in the first volume of the 'American Journal of Mathematics' (1878).

At the beginning of the "Researches" Mr. Hill divides the periodic developments of the lunar co-ordinates into classes of terms, and proposes to treat the following five classes of inequalities:—

1. Those which depend only on the ratio of the mean motions of the Sun and Moon.
2. Those which are proportional to the lunar eccentricity.
3. Those which are proportional to the sine of the lunar inclination.
4. Those which are proportional to the solar eccentricity.
5. Those which are proportional to the solar parallax.

He also promises a general method by which these investigations may be extended so as to cover the whole ground of the Lunar Theory.

Only two chapters of the "Researches" were published: the first relates to the general differential equations of motion, and the second to the first of the five classes of inequalities mentioned above. The memoir on the motion of the perigee belongs to the second class; so that we are practically in possession of Mr. Hill's general methods and their applications to two out of the five classes of inequalities.

After giving a detailed account of Mr. Hill's investigations, and referring to some of Prof. Adams's researches which have followed a parallel course, the *President* concluded as follows:—

I have now described, though necessarily in a very imperfect manner, Mr. Hill's mathematical researches upon special problems in the lunar theory, the originality and peculiar value of which the Council have been especially desirous of recognizing by the award of their medal. I can refer but briefly to Mr. Hill's other important contributions to physical astronomy, most of which, however, have been already noticed in our Annual Reports.

The American 'Journal' contains two other papers of his. The first of these, in the fourth volume, is a short note on "Hansen's General Formulæ for Perturbations," in which an equation of Hansen's is expressed in a form which is not only more simple, but also more convenient for computation. The second, in the sixth volume, is entitled "On Certain Possible Abbreviations in the Computation of the Long-Period Inequalities of the Moon's Motion, due to the direct action of the Planets." Hansen has characterized the calculation of the coefficients of these inequalties as extremely difficult; but Mr. Hill finds that if the shortest methods are followed this is no longer the case. In this characteristic paper, Mr. Hill, following the principles which, as we have seen, have guided him in all his work, attacks the question from the very beginning by a direct analytical investigation. He thus obtains finally, not only a new method for the actual computation of the inequalities, but also some results of mathematical interest.

Three elaborate memoirs have been published by Mr. Hill among the astronomical papers prepared for the use of the 'American Ephemeris' and 'Nautical Almanac':—(i.) "On Gauss's Method of computing Secular Perturbation, with an Application to the Action of Venus on Mercury" (1881); (ii.) "Determination of the Inequalities of the Moon's Motion, which are produced by the Figure of the Earth: a Supplement to Delaunay's Lunar Theory" (1884); (iii.) "On certain Lunar Inequalities, due to the Action of Jupiter, and discovered by Mr. E. Neison" (1885).

The object of the first of these papers is to reproduce in a form practically useful for astronomers the results given by Gauss in his celebrated memoir, "Determinatio Attractionis, &c." In the original memoir the method is not presented in such a manner that it admits of easy application to an actual case. In this paper Mr. Hill places Gauss's process within the reach of any computer possessed of ordinary mathematical knowledge. Gauss's investigation is reproduced in full, with the addition of the details necessary for its application; and, finally, the formulæ themselves, in the shape in which they are required by the practical calculator, as well as the necessary tables of elliptic integrals, are given. As an example, the computation of the secular perturbations of Mercury, produced by the action of Venus, are worked out, the final results agreeing very closely with those of Leverrier. It is to be hoped that this paper may have the effect of bringing into more general practical use Gauss's very beautiful and perfect method.

The second memoir is described by the author in its title as a supplement to Delaunay's Lunar Theory. At the time of Delaunay's death the inequalities caused by the disturbing action of the Sun were complete; but the small effects produced by the spheroidal figure of the Earth, and other minor portions of the subject, were untouched. Mr. Hill's object in this memeir is to supplement Delaunay's great work by determining, in a literal form, all the inequalities of the Moon which arise from the figure of the Earth to the same degree of algebraical approximation as that adopted by Delaunay in determining the solar perturbation—that is, to terms of the seventh order inclusive. The value of a constant which enters into the coefficients and depends upon the figure of the Earth is determined by an elaborate discussion of numerous pendulum experiments; and by the substitution of the values of m, e, e' γ, and this constant, the numerical values of the coefficients are deduced. The whole of this elaborate investigation seems to have been carried out with great skill and care.

In the third of the memoirs referred to, Mr. Hill effects the determination of the coefficients of two lunar inequalities, due to the action of Jupiter, to which Mr. Neison drew attention in Vol. xxxvii. of the 'Monthly Notices.' Mr. Hill's value of the second of these inequalities amounts to only about one tenth of that assigned to it by Mr. Neison.

It is nine years since Mr. Hill undertook for the office of the 'American Ephemeris' and 'Nautical Almanac' an investigation of the motions of Jupiter and Saturn with the view of constructing tables of these two planets. From its commencement this great work has occupied nearly the whole of his time; and, even if no hindrance occurs, it must continue to do so for the next three or four years. It is well known that the theory of Saturn is in an unsatisfactory state, Leverrier's tables failing to represent adequately the observations. A special interest therefore attaches to these new investigations, which have been carried out by means of Bessel's very refined methods. The work has so far progressed very satisfactorily. The final expressions for the co-ordinates of the two bodies, together with the details of a preliminary comparison of them with observations made for the purpose of ascertaining what corrections the perturbations might need on account of errors in the provisionally assumed elements, were published last year in the 'Astronomische Nachrichten' (Nos. 2705–2706). When these investigations, in which the approximations are carried to a much greater extent than in any previous treatment of the subject, are completed, the whole will form by far the largest and most complete investigation of the kind that has yet been performed on the American continent.

It is doubtless due to the engrossing character of this work that only two chapters of the 'Researches on the Lunar Theory' were published. There is abundant evidence that Mr. Hill's researches must have been extended far beyond those given in these two chapters at the time when his new labours deprived him of the leisure necessary for completing and preparing them for press; and I trust that when the Theory and Tables of Jupiter and Saturn shall have been published, Mr. Hill may be enabled to resume his mathematical researches at the point at which their publication ceased, and to carry out his original intention to its full extent.

The President, then, delivering the Medal to the *Foreign Secretary*, addressed him in the following terms:—

Dr. Huggins,—May I ask you, in transmitting this medal to Mr. Hill, to assure him of our high appreciation of the value of his contributions to physical astronomy, and to express to him our earnest hope that his life may long be spared, and that he may have health and strength to complete the splendid work upon which he is now engaged, and to enrich our science still further by his mathematical researches.

General Walker. I move "That the Report of the Council now read be received and adopted, and that it be printed and circulated in the usual manner, together with the President's Address and the Report of the Auditors."

Mr. Newall. I second the motion.

The motion was put and carried without discussion, and the meeting proceeded to the transaction of "Special Business."

Mr. Ranyard. The resolution of which I have given notice is "That the following words be added to Bye-law 75—'nor unless the nominee selected be a foreign astronomer not resident in Great Britain.'" Bye-law 75 reads at present: "No medal shall be awarded in any other way than in the manner and at the time above prescribed, nor unless three fourths at least of the Members of the Council shall agree thereto." My motion would make it read—"nor unless three fourths at least of the Members of the Council shall agree thereto, nor unless the nominee selected be a foreign astronomer not resident in Great Britain;" that is to say, that in future medals should not be given to astronomers resident in Great Britain. I should like your very patient consideration to the matters I am going to lay before you; because this is a self-denying ordinance. I know that I am going to ask you to go against the stream. I feel it is a difficult matter to urge, but it is an important one, or I should not have undertaken it. I am asking you, as a fountain of honour, to behave like all other fountains of honour, and not on any occasion to bestow the medal on yourselves or anybody connected with you. The House of Lords does not make Lords. At the Bar all distinctions are conferred by an outside authority. From our schooldays upward it is the same thing. Magistrates, when they grant licenses, if they are in any way connected with the grant, even in the most indirect way, think it necessary to stop away; and so it is on the Judicial Bench, if a judge is concerned in a case he immediately withdraws. It has long been recognized as only consistent with his dignity to do so; and for the dignity of this Society I urge that we should do the same thing. We should put ourselves entirely above suspicion, like Cæsar's wife. We should make a better choice too, I think, if we did so; because a prophet is never esteemed in his own land. There are all sorts of proverbs one might quote. A man in his own family is either over-estimated or under-estimated. We never form as just a judgment about those who are immediately connected with us as we do of those who are at a distance. With regard to those who are nearly connected with us, there may be jealousies or there may be friendships which may upset our judgments, one as much as the other. There is only a small body of workers at any particular science, and there is a tendency to form cliques that upset the scientific spirit, and if the scientific spirit is upset the work will be upset; I believe that people do better work when they do it with the highest and best motive, and without any personal interest about it. Last year when I brought forward this subject, the only argument that was urged in favour of medals was urged by Mr. De la Rue, but all he could say was that it was a pleasure to us to give medals—that it was such a pleasure that we could not give it up. Now I do not think that is an argument at all.

Mr. Common. I rise to order. Mr. Ranyard in quoting Mr. De la Rue is not giving his words. Mr. De la Rue said that the

Society in giving medals was honouring itself as much as honouring the recipient of the medal.

Mr. Ranyard. I think he said that in addition to what I have stated.

The President. The words he used were, I think, that it was a graceful act of recognition.

Mr. Ranyard. But at all events we cannot say that because it is pleasant to give medals, therefore we should go on giving them. It is not an argument. The only sort of argument that I should recognize is that it is good for our science, that the Society is better for it, and that the individual workers do better if they think there is a chance of gaining the medal. But it seems that that cannot be urged. Anything which promotes jealousy amongst specialists must do harm, and there is great urgency in the race for the hall-mark or medal, between specialists. They feel it very acutely indeed. I do not wish to take any English instance; but I will give you a few French instances in the beginning of this century. A man like Arago, who was a pleasant biographer, and who never said anything unpleasant, tells us of men struggling earnestly in France, where they are fond of decorations, and being upset for the whole of their lives and being soured. He speaks of Fourier, who gained the great mathematical prize at the Academy of Sciences, with his great work on the Production of Heat, in 1812. There was some criticism in the address that was given on the occasion, and Arago says "Fourier never admitted the validity of this decision. Even at the close of his life he gave unmistakable evidence that he thought it unjust by causing his memoir to be printed in our volumes without changing a single word. Still the doubts reverted incessantly to his recollection. From the very beginning they had poisoned the pleasure of his triumph. These first impressions, added to a high susceptibility, explain how Fourier ended by regarding with a certain degree of displeasure the efforts of those geometers who endeavoured to improve his theory. This, gentlemen, was a very strange aberration in a mind of so high an order."

Some persons imagine that people who study science are necessarily above all human feelings; but it is not so. (Laughter.) I am glad to hear that laugh, because that is a great point in the argument. The advancing of Science is done by men who are frequently, in other directions, weak men; we ought to do everything to prevent their weakness coming up; it will make it easier for them and easier for all workers if these distinctions are abolished, and they will then be juster to one another, and will lead healthier and better lives. Arago in speaking of Malus, the discoverer of polarization from the reflection of the light from the windows of the Luxembourg, says, after stating that he was not a member of the Academy and that he had been in the army and had fought in Egypt: "Among the candidates there was conspicuous an engineer of roads and bridges, who had also borne a part in the Egyptian expedition, and whose connections with the Academicians were numerous and of old date. Every one, therefore, foresaw that the place would be vigorously contested. On the day of the Election, Aug. 13, 1810, one of Malus's friends undertook to bring him the news of the result the moment it was known. But by an unfortunate combination of circumstances the scrutiny was not opened till a later time than usual. Malus obtained 31 votes, his opponent 22. The friend alluded to did not lose a moment in going to announce the result. But the usual hour at which the news ought to have reached him having long passed, the great physicist believed himself to have been defeated, and abandoned himself, in spite of all the consolations which his wife afforded him, to the deepest despondency. Thus the intrepid soldier of the army of the Sombre and Meuse, he who had seen the near approach of death, &c., allowed himself to yield and sink under the supposed want of success in an election of the Academy." It is a thing that upsets men—this striving after the hall-mark; and I say this proposal of mine would take that difficulty out of the way. Perhaps we are not so fond of decorations as the French, and if so it is all the easier for us to give them up. There is just one other quotation from Arago that I should like to read, to show how the Institute upset Arago's judgment. He had written a life of Fresnel. It was a time of great political excitement in France, and he had had his political allies, and some had patronized him; but one minister did not patronize him, because he was on the other side. Arago was begged to take some lines out of the *éloge* of Fresnel. Some of his friends said to him "If you execute your project the Institute will be abolished; nor have you, the youngest member of the Academy, any right to provoke such a catastrophe. And to support this demand they pointed out to me several savants whose sole livelihood lay in their appointments as members of the Institute. These observations, strongly represented, shook my determination." He did modify considerably his judgment because of these strong feelings. I should like to point out that it would be very much better to let people rely on their work than on a hall-mark. A man really does get a great deal of honour from his work if he does it honestly and well; and it is as well to keep people looking to those who can really judge, and to their own consciences, rather than to popular applause, for the reward of their work. I don't think that can be doubted. Last year it was pointed out that work was not done for the medals. I do not think it is, but that there is something else which pushes them forward: and therefore medals do not make men work. I say it hinders work, and I should like to hear what can be said for their not hindering work. The men who get the medals do not get them till they have earned their laurels, and do not want patronage; and if they do want the medals, it is a pretty good indication that they ought not to have them.

Mr. Franks. I have great pleasure in seconding the resolution which has been proposed, not merely as a matter of form, but because it has my hearty sympathy. I think by limiting the award of medals to foreigners we shall raise the *morale* of the Society.

Prof. Adams. It seems to me that if Mr. Ranyard makes this proposal seriously he ought logically to carry it far beyond the point at which he stops. He ought to propose not that we should confine our medals to foreigners, but that we ought not to give any medals at all. What right have we to demoralize foreigners by proposing them for medals any more than our own people? [Laughter.] Therefore Mr. Ranyard should enlarge the scope of his proposal. Further, according to Mr. Ranyard's argument, even if we award medals to other foreigners, we ought not to award them to any of our foreign associates. Generally speaking, we have picked out the most eminent men we could find to be our associates. We should have to say to these distinguished men, "Remember, that by thus associating you with ourselves, we put it out of our power to award you our medal." That does not appear to me a very rational proceeding. As to the idea of demoralizing our own people by giving medals, I do not think Mr. Hill, who did his work 10 years ago, will find himself much demoralized by now receiving our medal. When he wrote his valuable paper, of which we have had such an excellent account this afternoon, he did not think about getting a medal for it. Had he done so, we should probably never have selected him for the medal. We select a man because we think he has done his work worthily, and that he had a good motive in doing it. One fact is clear, if we cease to give medals we shall suffer in one way—we shall not have the pleasure and the advantage of listening to such an admirable address as that which we have just heard from our President. [Applause.]

Capt. Noble. I am a little disposed to move an amendment to Mr. Ranyard's motion. I think that as good work has certainly been done in England as has ever been done abroad, both in mathematical and observational astronomy, and I do not see, if foreigners are to have medals, why Englishmen, if they earn them, should not have them too. But I agree with one thing which fell from Mr. Ranyard, and that was, that, like Cæsar's wife, we should be above suspicion. There is a rule in the Geological Society that no member of the Council can receive a medal so long as he holds office, and that rule has been found to work very well. I think we might go as far as that, and say that we would not give a medal to one of our own body so long as he was holding office; but beyond that I would not go. If the meeting would be disposed to accept that as an amendment, I would propose it; or I would merely throw it out as a suggestion.

The President. Will you move it as an amendment.

Capt. Noble. I think it would be worth while.

Mr. Sadler. I will second the amendment.

Mr. Nightingale. There is certainly something ingenious in the amendment Capt. Noble has put, and it has a good deal of merit in it. There is no doubt that with regard to the award of medals, in a Society like this, where the Council is made up of the very best men on the subject, a large number of medals must of necessity fall to their lot. Thus we have the curious position of the Council giving medals to itself, so to speak. I think there is no other body in the world in which such a curious anomaly is found, and those in favour of the present system must show very cogent reasons why the rules of this Society should support an anomaly so extraordinary. At the same time, though Capt. Noble's amendment was designed to remove this anomaly, and although it meets the difficulty in its direct form, it does not seem to my mind that it quite meets it in the indirect. Mr. Ranyard has put it very clearly that friendship has its influence, and if the Council awarded a medal there is no doubt that *possibly* mutual feelings might crop up. Of course, we have no right to make any insinuations, but it is this point that Capt. Noble does not meet in his amendment. But why give a medal at all? It has been admitted on all hands that it does not encourage work. If it is liable to introduce jealousies and party-feeling amongst the members, if it is liable to set members, who would otherwise be friendly, at loggerheads, why carry on this procedure? It is somewhat curious that it should exist. I have never yet discovered that any other reason was given for awarding prizes—awarding mere emblems which represent work and success—except to excite ambition. Under these circumstances, though I think the amendment has a great deal to be said for it, I shall support the original motion.

Capt. Noble. I put forward my amendment simply that any one outside could have no ground for suspicion. I sat upon the Council for 13 consecutive years, and I defy anybody to say a word against the enormous pains which are taken to obtain proper men as recipients of the medal. The different members of the Council nominate each his own candidate, but every one has to give a reason for nominating him. So far, I can go with Mr. Ranyard, but I think we ought to be above suspicion. I think we should remove that suspicion if we say that we would not give the medal amongst our own body. It is a very simple thing for a man to go off the Council and receive the medal, and he can go on again when he has got it.

Prof. Adams. It must be remembered that no member of the Council can vote for the award of the medal to himself, which at once disposes of the objection raised in Capt. Noble's amendment, that members of the Council can really decree the medal to themselves, unless it be done indirectly on some such understanding as this: "If you vote for me this time, I will vote for you next." I never heard of any suspicion that that had ever been done.

Capt. Noble. Do not imagine I bring any such charge. I say it for the sake of those outside.

Mr. Bryant. If each of the 21 officers have a secret suspicion or hope that they may get the medal next December, must they all send in their resignations at the first meeting in December? If so, how would the medal be awarded?

Mr. Stone. I think it would be desirable for the Secretary to read the Bye-laws which relate to the award of the medal, to show the precautions that are taken against a few men carrying a candidate of their own.

Mr. Sadler. May I ask how many are present when the medal is awarded?

Mr. Ranyard. There must be five.

General Tennant. As a matter of fact, I think a majority of the members of the Council are present on an occasion like that. If the award of the medal to a member of the Council would create so much jealousy in that body, I think it must be perfectly evident to all that that very jealousy would render it impossible for him to get the medal unless his claims to receive it were exceedingly strong.

Mr. Knobel read the rules bearing upon the awarding of the medal. He said: I may add as a matter of information what the procedure is: at the November meeting the names of nominees for the medal are proposed, and the reason for such nomination mentioned in the briefest language. [The list of nominees is at once printed, and a copy forwarded to each member of the Council.] At the December meeting each candidate is thoroughly considered, and the claims are discussed in the most minute and careful manner the Council have time to bestow upon them. In the January following, the procedure according to the Bye-law is that they shall decide whether the nominee before the Council shall or shall not receive the medal—simply to confirm it or not.

The President said he proposed to put the question to the meeting whether Mr. Ranyard's proposition be amended. That is, Mr. Ranyard had given notice of a resolution; Capt. Noble had proposed an amendment. It rested with the meeting to decide whether they would permit the motion to be so amended. If they voted "Yes," Mr. Ranyard's motion passed away entirely, and Capt. Noble's amendment became the substantive motion. If they voted "No," Capt. Noble's amendment fell, and Mr. Ranyard's motion would be the one before the meeting. So the question for the Society was not the amendment itself, but whether the original motion be amended.

Mr. Ranyard then made a few remarks in reply, and said he was perfectly serious in the course he had taken. He would not exclude Associates from the medal, since they had not the power of voting on it. He thought *éloges* bad because they tended to flattery and because the outside world judged of men's merit by them. It was far better that every one should stand on his own deserts.

The President then put the question whether Mr. Ranyard's motion should be so amended, and the amendment was defeated by a large majority. He then put Mr. Ranyard's motion, which was also lost.

The President appointed Messrs. Hunt, Knott, and Bryant as

Scrutineers of the Ballot, and the Meeting proceeded to the election of Council and Officers for the ensuing year. The following was the result of the Ballot:—

President: J. W. L. Glaisher. *Vice-Presidents*: Prof. Arthur Cayley, W. H. M. Christie, The Earl of Crawford and Balcarres, and Edwin Dunkin. *Treasurer*: A. A. Common. *Secretaries*: E. B. Knobel and Lieut.-Col. G. L. Tupman. *Foreign Secretary*: Dr. William Huggins. *Council*: Capt. W. de W. Abney, Prof. J. C. Adams, J. Rand Capron, G. F. Chambers, J. R. Hind, E. W. Maunder, Capt. William Noble, Rev. S. J. Perry, A. Cowper Ranyard, E. J. Stone, Lieut.-Gen. J. F. Tennant, and H. H. Turner.

Liverpool Astronomical Society.

THE usual monthly meeting was held on Monday, February 14. The chair was occupied by Mr. W. D. H. Deane, M.A. 17 Members were elected and 23 candidates were proposed; and his Imperial Majesty the Emperor of Brazil was elected an Associate of the Society.

The Secretary said he had an important matter to put before the meeting. The Pernambuco branch had now become so extended as almost to form a Society in itself. At present, owing to the uncertainty and delay of postal communication, it was quite possible for a candidate not to receive official notice of his election until nearly five months from the date of his nomination; and of course the difficulty was felt in other ways. Under these circumstances, they had asked for the power of electing their own members, and a president and local executive, so that they might be enabled to hold meetings and pass such bye-laws as might be found necessary for their welfare. It was understood that all decisions were to be subject to the confirmation of the home council. Strictly speaking, this was a matter which rested with the Council only; but, though they were not unwilling to grant the concession, the question was of so much importance that they preferred its being discussed at a General Meeting.

The President (the Rev. T. E. Espin, B.A.) in a letter expressed his pleasure at finding the South-American members deemed themselves strong enough to form a local branch. Although perhaps some might say that such a course was inexpedient, yet, for his part, it seemed that as the objects they had in view were the growth of their science, nothing could be more in keeping with the Society's aim than the formation of local and quasi-independent branches. Whilst preserving its attachment to the old Society, the new branch would itself be a centre from which, in due course, other branches might be put forth in South America. The constitution of such a branch as was contemplated would need care, and should be so formed as to consolidate their relations, and, at the same time, to leave perfect freedom to each other. He (Mr. Espin) would suggest that the head of the new branch be not called president, because the head of a Society like the L. A. S. is, *ipso facto*, president of all its branches, but *vice*-president, and, as such, being head of the especial branch and at the same time having an office in the home society next to the president himself. This would involve no alteration in the Council-list, and in the next election the head of the Pernambuco branch could be put on the house-list. By this means they would escape any fresh alteration of the Bye-laws.

Mr. S. Maitland Baird Gemmill considered there was no doubt that, since the branch had increased to so large a size, they might reasonably claim a measure of self-government, and whatever they might reasonably claim ought certainly to be granted. There was, however, this difficulty: if the branch had uncontrolled power of electing *new* members, it virtually became an independent society; whereas if these elections, like the "decisions," were to be subject to the confirmation of the home council, it was difficult to see what advantage they would gain.

Mr. Thos. Gwyn Elger quite agreed as to the justice of granting home-rule to their Brazilian friends.

Mr. James Gill was strongly in favour of granting home-rule to all the branches. Without some form of local government it would be impossible for distant members to hold meetings, and so to encourage each other in a study of the science. As long as their regulations were subject to the control of the home council he did not see that there could be any objection.

Mr. C. A. Defieux said the isolated position of the South-American members gave them every claim to their sympathy. He thought it might well be left to the discretion of the members what title they gave their officers, since it would only have a local significance, and would not affect their status.

Mr. J. L. Coxon asked whether the course that had been proposed would affect the amount of their subscriptions, as he understood that this was already too small to cover the expenditure.

Mr. Davies replied that the difference would, if anything, be in their favour. Foreign correspondence was rather a costly luxury and there would also be some saving in the carriage of parcels. The local expenses would, of course, be borne by the members themselves; but it was only fair that each branch should be supplied with stationery and other necessary items. It was not, however, entirely a question of economy. The Society had now become so widespread that some such division was absolutely necessary if the work was to be carried on. He did not think the responsibility of the Society ended with supplying publications which, however valuable they might be in other respects, were not always suited to the requirements of beginners. Astronomy appeared to be rather backward in South America, and there was besides a scarcity of astronomical works. To make up for this there was plenty of enthusiasm, and monthly circulars were issued by the more advanced members, containing a glossary of astronomical terms, and such other information as they thought might be useful. A taste for the science had evidently been awakened, and it lay with the members of the home society to say whether it should be encouraged.

The Chairman said if there were no other remarks he would put it to the Meeting in the form of a Resolution, which, being done, was unanimously adopted.

Mr. W. H. St. Q. Gage submitted a list of coloured stars which he had observed during his late residence in India. The observations had been made with a 4½-in. refractor at an altitude of 6000 feet.

A paper on the proper motion of 40 (o^2) Eridani, by Mr. J. E. Gore, was read. In addition to the binary companion to this interesting ternary system two other faint *comites* had been measured, and from these measures he had computed the proper motion of the principal star. This afforded a mean result of 4″·04 annually in the direction of position-angle 212°·4.

Miss E. Brown called attention to a possible transit of Vulcan across the Sun's disk during its approaching node, which, according to Oppolzer, was due on the 18th March.

Papers were also read on the variability of *Ll* 14551 (U Puppis), by Mr. Herbert Sadler; on the Merope Nebula, by Mr. W. H. Wesley; on the Lunar Straight Wall or "Railroad," by Mr. T. G. Elger; on Typical Sun-spots, by Major E. E. Markwick; on a Suspected Variable in Ursa Major, by Mr. S. M. Baird Gemmill; on Secular Change of Climate, by Mr. M. Fergus; and Mr. W. F. Denning continued his series of papers on Telescopes and Telescopic work.

Selenographical Notes.

LEVERRIER AND HELICON.—A very interesting phenomenon may be observed in connection with the latter of these formations if it is examined at sunrise. A prominent ridge commencing some distance north of Leverrier and following a bold regular curve (convex towards the east) skirts the terminator up to the north border of Helicon, and, reappearing on the south of the ring, ultimately terminates at or near the bright crater Helicon *b*, its direction roughly bisecting the ring-plain, whose walls exhibit manifest gaps where it abuts on them. In the northern portion of its course it is joined nearly at right angles by a second ridge, the two causing at this stage a most remarkable notch or re-entering angle in the otherwise even outline of the terminator. Schmidt is the only selenographer who represents the association of Helicon with the principal ridge, and I cannot find the slightest allusion to the very remarkable appearance of the morning terminator through the Mare Imbrium when its longitude is about 22° East in any description of the ring-plain, though it is impossible to overlook it at this stage. The question arises, was the ridge a subsequent formation to Helicon, whose north and south walls have apparently been partially fractured by it, or was the ring-plain formed on the crest of the ridge? If the former we should expect to find, as in the case of Mädler, prominent evidence of its existence on the floor; but the interior is a very deep pit, 13 miles across, far below the level of the surrounding country, and exhibits only faint indications of detail, either low hills or craterlet (the latter first seen by Webb, 20th April, 1861). Hence it seems more probable that the ridge is anterior to the ring-plain. The border of the latter being formed of matter ejected from a vent situated on a "saddle-back" or anticlinal surface, would more probably show a break or opening in the direction of the axis of the ridge than elsewhere. Be this, however, as it may, the phenomenon is well worth the attention of the observer. At $8^h\ 30^m$ on February 2nd, when the east longitude of the morning terminator was about 24° 45′, the shadow of Helicon was estimated as equal in length to the major axis of the ring, and a conspicuous crater was noted in contiguity with its northern edge. The companion ring-plain, Leverrier, has a crater on the outer slope of its southern border, which at sunrise considerably modifies the form of the shadow. There is a smaller object of the same class on the northern wall causing an apparent notch. Schroeter saw a central peak in Leverrier as well as in Helicon, but it has not been recorded since his time. There are a number of small craterlets in the region surrounding these ring-plains and many faint ridges. A complete map of this portion of the Moon's surface founded on observations made at various stages of illumination would be useful, and a work well within the power of the owners of moderate apertures to carry out.

SUNRISE ON PLATO.—At $6^h\ 0^m$ on February 1st, when rather more than half the area of the floor was illuminated, the spires of shadow due to the lofty peaks on the western wall were smudgy and indistinct. This was more particularly the case with the shadows of γ and δ. That of the former extended on to the inner slope of the eastern border, and was scarcely distinguishable from the surface of the strip of floor to the south of it, while that of δ was equally blurred and misty. Though this obscurity prevailed *within* the walled plain, the shadows of objects *outside* were remarkably sharp and clean cut. This appearance has been noted on a few previous occasions; but from a long acquaintance with the phenomena both of sunrise and sunset on Plato, I believe it is only occasionally presented, and that it is due to some purely local cause.

Kempston, Beds., 1887, Feb. 18. THOMAS GWYN ELGER.

The Chromosphere in 1886.

During the past twelve months the chromosphere has been measured more frequently than in any year since 1880, and the results should in consequence be more trustworthy. The mean height of this gaseous solar envelope does not vary much from year to year, but the prominences that spring out of it have scarcely attained in 1886 the height of preceding years, and their number and extent is much diminished.

	No. of days of observation.	Mean height of chromosphere excl. prominences.	Mean height of prominences.	Mean extent of prominence arc.	Highest prominence.	No. of days on which C was displaced.
		″	″	° ′	′ ″	
January	9	8·25	23·92	15 42	1 22·00	1
February	8	8·12	23·07	14 16	1 0·24	1
March	10	8·21	26·06	14 57	0 57·68	0
April	11	8·12	28·19	22 49	1 54·49	4
May	6	7·99	23·92	11 9	1 13·47	2
June..........	8	7·90	21·79	13 26	1 25·02	1
July	10	8·07	27·77	19 51	1 22·45	1
August.........	5	7·95	29·48	12 29	1 23·31	1
September	7	7·86	24·35	11 39	0 53·40	2
October	10	7·99	23·50	9 54	1 25·44	2
November	6	8·12	20·51	7 25	0 40·59	0
December	11	8·07	24·78	9 31	0 53·40	4
Mean for 1886..	8·4	8·05	24·78	13 36	1 12·77	1·6

Incomplete observations were made on two other days.

The bright line K. 654·3 was seen in January, February, and March, but has not been observed since. S. J. Perry.

Stonyhurst Observatory, Lancashire.

Meteor Notes.

In singular contrast to the preceding month, January 1887 proved very cloudy and gloomy; there were only two nights when observations of satisfactory length could be obtained. On the 19th the sky cleared after heavy rain, and between 13ʰ 30ᵐ and 16ʰ 45ᵐ I saw 22 meteors. On the 25th, during a watch of 5½ hours between

$10^h\ 30^m$ and $16^h\ 30^m$, I recorded 26 meteors; and a few others were observed on the evenings of the 20th and 27th. Altogether 57 were counted in 13 hours of watching. The visible horary number for the month exhibits a still further decline compared with the results for November and December 1886 ('Observatory,' Jan. p. 102).

The following showers are the only ones to be relied upon from my scanty observations, and in regard to two of these I have found excellent confirmation amongst my results in 1877:—

1887, Jan. 25	180°	+24°	Meteors swift. Obs. by Zezioli in 1869 Jan. 11–12 at 183° +28° (S. & Z. 5).
1877–87, Jan. 14–25 ..	208	− 8	Meteors very swift, with long paths and streaks. Obs. by Tupman 1870 Jan. 5–11 at 210° −6° (T. 6).
1877–87, Jan. 14–19 ..	253	+56	Meteors very slow, yellow. A new shower 2° N.W. of μ Draconis.
1887, Jan. 19–25	261	+63	Meteors rather slow. New shower 4° S.E. of ζ Draconis.

On Jan. 25 radiants were also suspected at 107° +41°, 132° +31°, 209° +52°, and 291° +52°. During the night I observed two stationary meteors, one at 180° +24°, the other at 291° +52°.

The brightest meteor seen here in January was on the 20th, at 6^h 48. It was = ♃ and fell very, very slowly from 146° +36° to 168° +35°. Duration of flight 5 seconds. Its colour was orange-red; radiant uncertain, but probably on the N.E. confines of Orion. Another fine meteor was recorded on Feb. 2nd at $15^h\ 44^m$, with a path from about 68° +84° to 60° +68°; but it was not well seen, owing to the clouds which prevailed.

Bristol, 1887, Feb. 10. W. F. DENNING.

The Motion of a Comet when Perturbed and Resisted.

IN what follows we consider the disturbing planet unresisted, all other cases can easily be reduced to the same.

We shall further suppose all the inequalities due to perturbations to be divided into two classes:—1st, the long inequalities nearly approaching commensurability due to Jupiter; 2nd, all the rest of the inequalities. We need only for our purpose consider the first class.

The effect of the resisting medium during one revolution of the disturbed body will be of form $\beta n^{-\frac{2}{3}}$ if density of medium be constant, and βn^{3} if the same vary inversely as square of the distance. β may be considered as a constant not of the same value in both cases; n is osculating mean motion during unit of time. We shall include both forms in βn^{-q}.

It is usually considered that the result of a resisting medium is to procure a continuous secular diminution of the major axis, but this is not the case if density be constant.

Let m be the mean motion, u the argument of the long inequality, that is of lowest multiple:

$$U = \kappa_1 \sin u - \kappa_2 \sin 2u + \kappa_3 \sin 3u - \&c.$$

Let $\beta n = \beta n_0 \left(1 + \frac{du}{dm}\right)$ approximately, n_0 value of n when there is exact commensurability.

Then we have the general equation

$$\frac{d^2u}{dm^2} + q\beta n_0 \frac{du}{dm} + U - \beta n_0 = 0 \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Put for shortness $q\beta n_0 = \sigma$, and make two cases according as in the equation

$$\frac{du}{dm} + \int \left(U - \frac{\sigma}{q}\right) dm = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

when we put $u = v + \gamma$ (β being a constant) v can be determined as entirely a periodic function of m, or, secondly, when this cannot be done.

It may be well to observe that the complete form of (1) is really

$$\frac{d^2u}{dm^2} + \left(\sigma + \frac{dV}{du}\right)\frac{du}{dm} + U - \frac{\sigma}{q} = 0 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where $\frac{dV}{du}$ is of the same form as U; U, as is evident, includes the terms subject to double integration, whilst V includes the similar terms only subject to one integration.

We shall put for simplicity V = 0. Where the inequality is commensurable and the comet's orbit has, in relation to Jupiter's, two points of minimum distance, $\frac{dV}{du}$ will have a constant term which may be joined to σ. The solution of (3) when V = 0 will be

$$\frac{du}{dm} = C\epsilon^{-\sigma m} + \frac{1}{q} - \epsilon^{-\sigma m} \int \epsilon^{\sigma m} U dm \quad . \quad . \quad . \quad . \quad (4)$$

C being a constant.

The integral in (4), $\epsilon^{-\sigma m} \int \epsilon^{\sigma m} U dm$, is supposed to be entirely periodic, and the condition of commensurability will be

$$Ce^{-\sigma m}+\frac{1}{q}=0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Let the non-periodic portion of $\frac{du}{dm}$ be b, then we have

$$\frac{1}{q}-e^{-\sigma m}\left(\frac{1}{q}-b\right)-e^{-\sigma m}\int e^{\sigma m}\mathrm{U}dm=\frac{du}{dm} \quad . \quad . \quad . \quad . \quad (6)$$

If q be negative, σ is negative and the major axis diminishes indefinitely, never becoming, strictly speaking, commensurable, but passing through it for an instant when b is negative.

When q and consequently σ are positive, which most likely corresponds to the real case, when also b is positive, there is no commensurability till the non-periodic portion of $\frac{du}{dm}$ attains the limit $\frac{1}{q}$, and this is the case whether $\frac{\sigma}{q}$ fulfils the first condition of equation (2) or not. When b is negative and $\frac{\sigma}{q}$ does not fulfil the first condition of equation (2), then, although the non-periodic portion of $\frac{du}{dm}$ passes through zero, the motion, except at that instant, is never commensurable.

When, however, $\frac{\sigma}{q}$ does fulfil the condition above mentioned, b being negative, and we have

$$\frac{1}{q}-e^{-\sigma m}\left(\frac{1}{q}-b\right)=0,$$

then commensurability commences and the equation becomes changed to

$$\frac{du}{dm}=-e^{-\sigma m}\int e^{\sigma m}\left(\mathrm{U}-\frac{\sigma}{q}\right)dm \quad . \quad . \quad . \quad . \quad (7)$$

If we put $u=v+\gamma$, γ being a constant, v is by hypothesis entirely periodic. We shall have

$$\left.\begin{aligned} u=\gamma+a_1\sin\theta+a_2\sin 3\theta+\&c. \\ +\sigma(c_1\sin 2\theta+c_2\sin 2\theta+\&c. \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (8)$$

Where the coefficients $a_1\, a_2\, c_1\, c_2$ &c. being affected by the factor $e^{-\sigma m}$ to various positive powers all ultimately vanish, m approaches ∞, and the ultimate value of u is the limit of γ.

When the non-periodic portion of $\frac{du}{dm}$ has the limit $\frac{1}{q}$, that is $\frac{3}{2}$, we may reason as follows:—Let the argument of lowest multiple of system of long inequalities considered be of form $hM-kM_1+c$, where M and M_1 are respectively the mean longitudes of the comet and Jupiter, h and k are integers. When commensurability is not established, we have, as regards the non-periodic portion of $\frac{du}{dm}$,

$$\frac{du}{dm}=h\frac{dM}{dm}-k\frac{dM_1}{dm}=\frac{1}{q}-\epsilon^{-\sigma m}\left(\frac{1}{q}-b\right);$$

when limit is attained,

$$h\frac{dM}{dm}=k\frac{dM_1}{dm}+\frac{1}{q} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

which gives the ratio of the limiting value of $\frac{dM}{dm}$ to its original value. This value is probably hardly ever attained; but it may thus be shown that when σ is positive the diminution of major axis has a limit. In the case of this limit we have the equation

$$\frac{du}{dm}=\epsilon^{-\sigma m}\int\epsilon^{+\sigma m}\mathrm{U}dm \quad . \quad . \quad . \quad . \quad . \quad (10)$$

where U includes the system of new long inequalities thereto appropriate.

The actual course if σ be positive and b negative (b is supposed small) may be expected to be taking the following equation as basis, namely

$$\frac{du}{dm}=\frac{1}{q}-\epsilon^{-\sigma m}\left(\frac{1}{q}-b\right)-\epsilon^{-\sigma m}\int\epsilon^{-\sigma m}\mathrm{U}dm.$$

Suppose the comet-motion being supposed direct (corresponding to b negative), is smaller than that due to exact commensurability, and is increased by means of the exponential till exact commensurability is attained, in which state it remains with constantly diminishing coefficients as derived from equation (7) in the form (8), provided $\frac{\sigma}{q}$ fulfils the condition of equation (2). If this be not the case, then commensurability is only for a moment passed through, and non-periodic portion of $\frac{du}{dm}$ continues to increase till commensurability becomes again possible, and $\frac{\sigma}{q}$ fulfils the appropriate condition when compared with the new coefficients of U belonging to the new arguments of the fresh system of long inequalities. When this is so, commensurability remains with diminishing coefficients, and so on.

The higher the order of commensurability the less is it likely that $\frac{\sigma}{q}$ will fulfil the condition proper for the retention of that commensurability.

[illegible] When the period of the long inequality becomes [illegible] system begins to arise, which ultimately ends [illegible] asymptotic commensurability when the [illegible]

[illegible] commensurability has been established there is no secular [illegible] resistance: in fact, the absolute perturbations due [illegible] secular terms, which exactly neutralize those [illegible] explains the disappearance. But in the [illegible] the special perturbations, as in Encke's [illegible] terms due to resistance will appear. There is [illegible] theory caused by an abrupt change in the [illegible] resistance.

[illegible] commensurability has, I think, been already established in the [illegible] comet, and the bulk of the absolute perturbations [illegible] comet are included in the great periodic inequalities, which [illegible] $- \; 13J + 13\omega + \beta$, where E is mean longitude of Encke's [illegible] the same of Jupiter, $13\omega+\beta=$ a function of the elements.

W. C. EVANS.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Some further Notes on Binary Stars.

GENTLEMEN,—

Your readers will no doubt have corrected the misprint [illegible] occurs in my formula for the brilliancy of binary stars in [illegible] last number. The correct formula is

$$\frac{k_1}{k_2}=\left(\frac{I_1}{I_2}\right)\cdot\left(\frac{P_1}{P_2}\right)^{\frac{4}{3}}\cdot\left(\frac{a_2}{a_1}\right)^2.$$

[illegible] have since computed the brilliancy of σ Coronæ Borealis at [illegible] Ophiuchi at 1·16, and of ξ Boötis at 0·34. I have only [illegible] the brilliancy of binaries whose total light has been [illegible] photometrically, and may have omitted some even of [illegible]

[illegible] the very high brilliancy of γ Leonis, I may say that I [illegible] considerable doubt as to the accuracy of Dr. Doberck's [illegible] do not think the measurements of MM. Engelmann and [illegible], given in 'The Observatory' for November 1885, can be [illegible] with it, though they are in fair agreement with those of [illegible] observers. Before acquiescing in the startling results [illegible] and myself it would be desirable that the orbit [illegible] should be recomputed.

[illegible] Hall's recent investigations of the parallax of 61 [illegible] Cygni are rather calculated to throw doubt on the [illegible] investigations on parallax generally, I venture to suggest [illegible] stars may form a test of their value. If we used, as a comparison star, the minor star of such a pair, the relative parallax of the principal star ought to be zero. If observation led to this result, it would be some confirmation of the accuracy of the accepted methods; while if a sensible parallax was found, these methods would be further discredited. There are, moreover, many stars respecting which we are still in doubt as to whether they are binaries or only optically double. This point might be set at rest by measuring the relative parallax, if such measures can be relied on. If they are not physically connected, the relative parallax would probably be sensible.

The progress of spectroscopy may give us some additional information on the subject of parallax, as more than one writer has already remarked. If the angular dimensions of the orbit and the parallax of a binary star are known, we can compute the relative motion of the two components in the line of sight, and, conversely from the angular dimensions of the orbit and the relative motion in the line of sight we can compute the parallax. This method might also be applied to ascertain the correctness of the theory that variable stars of the Algol type are binaries, the minimum being caused by the transit of a dark satellite. As Algol and its satellite would, on this theory, revolve round on their common centre of gravity in a very short period, there ought to be a perceptible difference in the velocity of Algol in the line of sight when he is at different parts of his orbit. With all the stars of this class the diameter (and therefore probably the mass) of the dark satellite must be considerable when compared with that of the principal star, and the motion of the latter must therefore be considerably perturbed.

As regards 6 Cygni, I do not know what comparison star Professor Hall employed; but it occurs to me that he may have hit upon a star which belongs to the same system with the principal star, and that the small negative parallax at which he arrived is due to errors of observation, the true relative parallax being zero.

Though not connected with my subject, I hope you will permit me to conclude with a remark as to Mr. Lynn's letter on the colour of Sirius. I agree with him in attaching very little importance to statements on the subject by non-astronomical writers. I lately read a description of the Italian skies by Mr. Gallenga (quoted, I think, at second-hand, but without any remark by the writer who quoted it), in which he spoke of "the ruby Rigel and the sapphire Betelgeuse." As another specimen of such absurdities, I may refer to the note on η Argûs, in the 'Life of Sir W. R. Hamilton, late Astronomer-Royal of Ireland,' by the Rev. R. P. Graves, the second volume of which was recently issued from the Dublin University Press. Hamilton was not much of an astronomer, but *his* statement is perfectly correct, if his biographer had only let it alone. Some of the passages which are supposed to refer to Sirius, however, are probably intended for Procyon.

I remain, truly yours,

Dublin, 1887, Feb. 3. W. H. S. Monck.

Saturne—Trapèze d'Orion—Compagnon de Sirius.

Messieurs,—

Je crois le moment venu de vous donner quelques détails sur les observations de Saturne que j'ai faites jusqu'ici avec mon équatorial de huit pouces de Grubb.

Le 25 décembre 1886, je reçus la visite de M. l'ingénieur Tennstedt, d'Enghien, qui m'avait témoigné le désir de faire quelques observations avec mon réfracteur pour en éprouver la puissance. Le ciel étant d'une admirable sérénité pendant la soirée de ce jour, nous en profitâmes pour observer Saturne de 9 heures à minuit, avec les admirables résultats que voici :

La planète supportait très-bien les grossissements de 450 et de 650 fois ; nous apercevions la division d'Encke sous forme d'un trait noir sur les deux anses et cela sur une certaine étendue de celles-ci ; la division Cassinienne se voyait admirablement sur tout le pourtour, à l'exception de la région cachée par le globe. L'anneau B apparaissait formé de trois régions concentriques : l'extérieure très brillante, la moyenne très légèrement estompée, la plus intérieure très sombre. A l'intérieur de cette dernière se montrait l'anneau obscur, d'une teinte pourpre violacée ; il s'étendait jusqu'à la moitié de la largeur des lunules sombres ; chose remarquable, cet anneau obscur m'apparaissait séparé de l'anneau B par une division aussi noire que la division Cassinienne, peut-être plus large, apparaissant comme un ruban noir sur le fond sombre de ces régions ; il s'agit évidemment ici de la division de Struve.

Sur le globe lui-même, nous avons remarqué, en allant du nord au sud : 1°, la projection de l'anneau obscur ; 2°, les traces d'une bande sombre cachée en partie par l'anneau et apparaissant surtout vers les bords du disque ; 3°, une zone brillante ; 4°, une bande fine grise ; 5°, une zone très brillante ; 6°, une bande fine noire ; 7°, au dessus de cette dernière une région assez uniformément ombrée, rosée, s'étendant jusqu'à 8°, la calotte polaire plus sombre et très bleuâtre.

L'ombre du globe sur l'anneau se voyait sur l'anse occidentale ; elle semblait limitée par un bord concave sur l'anneau B, et ce bord se relevait en formant une saillie sur la division Cassinienne.

Nous avons jugé le bord du disque et le bord extérieur de l'anneau A tangents *à fort peu près au sud*, en inclinant plutôt à croire que le globe faisait une *très infime* saillie ; cependant, comme le bord de l'anneau semblait déprimé, échancré au contact du globe, nous ne considérons pas comme *impossible* que l'anneau fût en saillie *très légère, cette saillie étant alors cachée dans l'ombre du globe.*

Nous reconnûmes à la fois les satellites Japet, Titan, Rhéa, Dione, et Téthys.

J'ai continué mes observations de Saturne jusqu'à ce jour et je crois pouvoir dire que je n'ai pas encore retrouvé une occasion aussi favorable; j'ai revu pourtant tous les détails mentionnés ci-dessus et je les ai fait constater par d'autres personnes encore, notamment par M. De Heen, de l'Académie royale de Belgique, qui a vu comme moi la division d'Encke, et celle de Struve; nous avons, de plus, constaté la visibilité du globe *à travers l'anneau obscur* et observé le satellite Encelade. J'ai vu ce satellite difficile très régulièrement, et non seulement à l'époque de ses élongations. En ce moment l'anneau obscur semble toujours grisâtre et les divers détails semblent devenir plus difficiles à voir. Je dois dire que la division d'Encke m'a toujours paru plus visible sur l'anse occidentale et celle de Struve sur l'anse orientale. Mais j'aurai le plaisir de vous envoyer d'autres détails à ce sujet, de même qu'au sujet des apparences *successives* de l'ombre du globe que j'ai suivies avec grande attention.

Je me permets de vous citer un fait qui prouve avec quelle circonspection on doit envisager la variabilité apparente de certaines étoiles. La 5^e^ et la 6^e^ étoile du trapèze de la nébuleuse d'Orion ont été considérées comme variables par certains observateurs; je suis loin de contester cette opinion, mais je crois que l'observation suivante mérite d'être citée: hier, 7 février, *par le brillant clair de lune*, je dirigeai l'équatorial sur le trapèze, après avoir observé Saturne et Sirius avec le grossissement de 150 fois, et je fus stupéfait de voir la 5^e^ et la 6^e^ étoile avec *une netteté, une facilité inouïes*; sans doute la mise au point était d'une perfection remarquable. Cependant, comme il arrive souvent, je m'imaginai qu'il était possible de voir une image plus belle encore, et j'essayai de modifier un peu la mise au point. Aussitôt, tandis que la 5^e^ étoile restait bien visible, la 6^e^ devint plus difficile et disparut par moments. Je m'efforçai, mais en vain, de rétablir la mise au point primitive, je ne retrouvai plus cette admirable visibilité de la 6^e^ étoile que j'avais constatée d'abord.

Je fais en ce moment des essais sur la visibilité du compagnon de Sirius et de *Mimas* avec mon huit pouces, et j'aurai le plaisir de vous en faire connaître les résultats *.

Je vous prie, Messieurs, de bien vouloir me croire

Votre bien dévoué,

Louvain, le 8 février, 1887. Dr. F. Terby.

Photography and the Determination of Stellar Parallax.

Gentlemen,—

In the last issue of the 'Observatory' I find the report of a criticism on a communication of mine to the Royal Astronomical Society, which I think requires some brief notice on my part. Mr. Ranyard, according to your report, questioned the possibility of measuring (as I alleged that I had done) distances between stars

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* Je rouvre ma lettre pour vous dire que je viens d'apercevoir avec certitude le compagnon de Sirius.

impressed on photographic plates, so as to afford an accurate determination of the parallax of 61 Cygni. He expressed the opinion confidently that I had been measuring, as it were, the distances between heaps of shingle. If this opinion were correct my case would be pitiable indeed, for during the last eight months there have been made more than thirty thousand such measures on over two hundred photographic plates. If, however, I leave opinion and come to the unprejudiced facts of the case, I find that the star-images impressed are, thanks to careful manipulation, very definite, hard, black, circular dots, varying from about ·003 in. to ·005 in. in diameter, and there is of course no real difficulty in bisecting such circles as these. There is, indeed, a slight fringe of discreet dots visible round these images when viewed, for the purposes of measurement, with about the power of twenty on the microscope of the macromicrometer, but not such as practically to increase or interfere with the exactness of the measures.

The Astronomer Royal's responsible judgment is much more according to knowlege, and I entertain with him the conviction, expressed in your last issue, that "these accordant results obtained by the photographic method prove it really the best and most economical for determining the parallax of stars." These shingles must be subjective not objective; they certainly are not found on the photographic plates. I am, Gentlemen,

Your obedient servant,

C. Pritchard.

University Observatory, Oxford,
1887, Feb. 18.

The Argentine General Catalogue.

Gentlemen,—

In your brief review of Dr. Gould's last great work you have hardly, it seems to me, done him justice. You have not drawn attention to the astonishing amount of work executed at Cordoba generally or condensed in this Catalogue specially. It is simply amazing!—250,000 separate observations of both elements obtained with one instrument in scarcely more than seven years, and all completely reduced in three or four years more! Nothing like it has ever been known. They say comparisons are odious; nothing but a comparison, however, will give any idea to the majority of your readers what energy is implied in the above figures. The number of such observations obtained at Greenwich in seven years is about 25,000; at any other observatory in the world not half so many. Since its foundation in 1839 Poulkova, with its immense staff, has not in the aggregate produced so much work. The immense labours of Lalande, of Bessel, even of Stone at the Cape, sink into insignificance beside those of Gould. It is not possible, either, to say that the work was hurried, and therefore indifferent in quality. No detail, followed in any other establishment to ensure accuracy, was neglected at Cordoba. The magnitude of the work was only rendered possible by the interest taken in it by the indefatigable little band of assistants, amongst whom the names of John M. Thome and Eugene Bachmann are pre-eminent, the former being credited with no less than 35,000 observations, the latter with 33,000.

The works of Stone and Gould together, aided by that of Ellery at Melbourne, have now so turned the tables, that the southern heavens are more completely surveyed than the northern, and so they will remain; for not even the publication of all the zones of the Astronomische Gesellschaft will restore the equilibrium.

In your comment on the plan adopted for printing the Catalogue you almost find fault with the giving of each year's star-place separately. Writing in 1881 Dr. Gould feared that the publication of his observations in as complete a form as he would wish would occupy so much time as to render them almost useless. The form adopted is a compromise between the ledger and the condensed catalogue. Great as would be the advantage of having the ledger, its absence is in a great measure compensated for by the exhibition of each year's results separately; and as these separate results only differ in the last two units employed, the mean for any star can be read off with as much ease as any one set of figures. In such an immense Catalogue one would have hardly expected to find the annual precessions, yet not only the precessions but the secular variations are given. I am proud to testify my profound admiration for the mind that could, with unflagging energy and consummate ability, put in useful order such dismal millions of figures.

Harrow, 1887, Jan. 27. G. L. Tupman*.

The Outer Ring of Saturn: Encke's division?

Gentlemen,—

Following Mr. Stanley Williams's letter in your February Number, I would remark that the shading on the central portion of the outer ring has been seen with great distinctness during the present opposition, particularly so on the evening of the 26th Jan., when it was observed by Mr. Arthur Cottam at Watford, and by myself in St. John's Wood. This mark is now far more evident than it was in Dec. 1884, when, under a power of 600, and assisted by the finest definition, I could see but faint traces of it with my 18-inch speculum. Yours respectfully,

N. E. Green.

39 Circus Road, St. John's Wood,
1887, Feb. 17.

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* [Col. Tupman hardly does us justice, we think, in ignoring the notice we gave of Dr. Gould's work at Cordoba in general and of his Zone Catalogue in particular, in the Number of the 'Observatory' for January 1885, pp. 18–20. We yield to no one whomsoever in our admiration of Dr. Gould's energy and ability; we heartily agree with Col. Tupman in all that he says of the gigantic work he has accomplished; and we are glad to have this further opportunity of placing on record our appreciation of the high services which he has rendered to our science.—Editors.]

Break-circuit Chronometers.

Gentlemen,—

Will you kindly permit me to correct a slight error of stat ment which appears on page 55 of your January number, jus received?

Col. Tupman is mistaken in supposing that the three break circuit chronometers recently constructed by Dent are the firs instruments of the sort ever made in England. Parkinson an Frodsham fitted up one for me in 1877, and in 1878 I had it i use at our eclipse station near Denver, where our guest Mr. Ranyard, and, I presume, several other English astronomers, who a various times visited our camp, must have seen it.

At that time, however, break-circuit chronometers had cease to be a novelty in the United States. In 1872 the Coast Surve Observers had two of them in the outfit of our "Sherman Expedition;" and in 1874 all eight of the American Transit of Venu parties were supplied with them. I think the first was made b Bond & Co. of Boston, in 1870 or 1871; but Negus of N.Y., an other makers, at once followed suit. They have been in comm use here for more than 12 years, and have quite supplanted cloc in all field astronomy and in many small observatories.

Princeton, N.J.,
1887, Jan. 18.

Yours very truly,
C. A. Young.

NOTES.

The Six Inner Satellites of Saturn.—Prof. Asaph Hall c tinues in Appendix I. to the volume of Washington Observati for 1883 the important series of studies he has been making dur the last several years on the orbits of the satellites of the ou planets. The present memoir is concerned with the six in satellites of Saturn, Prof. Hall's leading purpose having been determine, if possible, the motions of the perisaturnia, since these could be accurately observed, the mass of the ring could found, Bessel's determination of the mass of the ring from motion of the perisaturnium of Titan being unsatisfactory, si the influence of the figure of Saturn was neglected. The ob vations of the satellites here discussed were made by Pr Newcomb and Hall with the great Washington reflector in 1 and the following years. For Rhea, Dione, and Tethys observed places have been compared with places computed from orbits found by Dr. W. Meyer and corrections to his eleme have been deduced therefrom. The result of the comparison sh that the orbits of all three satellites have practically no eccentric whilst circular orbits also satisfy the observations of Mimas Enceladus within the limits of probable error. The five in satellites of Saturn therefore move in orbits which are sensibly circular—a remarkable result which, of course, sets aside all consideration of the motion of their lines of apsides. Prof. Hall, however, draws attention to the fact that the observations at his disposal are not sufficiently accurate to afford the means of determining the eccentricity for the three inner satellites. Some more exact means of observation than that offered by the filar micrometer is needed; perhaps observations of the conjunctions of the satellites with the ends of the ring, the Cassinian division, and the sides of the ball might prove more effective.

Prof. Hall has computed the mass of Saturn from the elements found for the four outer of the six satellites observed, and obtains the following mean result:—$M = \frac{1}{3478{\cdot}7 \pm 1{\cdot}10}$, closely agreeing with Dr. Meyer's value, $M = \frac{1}{3482{\cdot}93 \pm 5{\cdot}50}$.

The five inner satellites move in the plane of the ring; or, at least, so nearly that they may be assumed to do so in all calculations of their motions. It is therefore easy to supply tables of their motions, and Prof. Hall furnishes them at the end of his paper, together with the elements of the ring for the period 1875–1950.

Total Solar Eclipse of 1886, August 29.—At the meeting of the Royal Society on 1886 Dec. 16, a preliminary account, by Capt. Darwin, of the observations of the eclipse of the Sun at Grenada in last August, was read. The principal interest of this communication relates to the results Capt. Darwin obtained with the coronagraph, a reflecting telescope arranged like that employed by Dr. Huggins for obtaining photographs of the corona at other times than during eclipses. The practicability of this method was to be tested in two ways—1st. By comparing photographs taken before or after the eclipse with photographs of the corona taken during totality, a similarity of form indicating that the corona had been photographed. No such similarity between the haloes on the plates exposed in full sunshine (of which a considerable number were taken on Aug. 28) and the true corona has yet been traced. 2nd. To take photographs during the partial phase; then, if the light of the corona produces any effect on the plate, the limb of the Moon should be visible against it. None of the plates taken during the partial phase show the Moon eclipsing the corona, and many show what is unmistakably a "false corona," *i. e.* an increase of density *in front of* the Moon. The results, therefore, are adverse to the possibility of obtaining photographs of the corona in sunlight; but Capt. Darwin does not consider that the method is yet proved to be impossible. The trial was not conclusive, because the conditions were very unfavourable. In order to reduce the air-glare to a minimum, the air should be clear and dry, the Sun near the zenith, and the station at a considerable elevation. But at the time of the eclipse the air was saturated with moisture, the sky of a hazy blue, the Sun low, and the station near the sea-level. It was also the general impression that the corona itself was not so bright as on other occasions.

THE TEMPLE OBSERVATORY.—Mr. G. M. Seabroke has published his Report for the year 1886. From it we learn that the instruments are all in good working order, and that another spectroscope, made specially for use on comets and faint objects, has been provided. Mr. Percy Smith has continued the measures of double stars during the year, 88 sets of measures having been made. Mr. Seabroke has been occupied with the measurement of motion of stars in the line of sight with the spectroscope on the reflector, and has completed 100 sets of measures. These observations, as well as the corresponding ones of previous years, have been published in the January Number of the 'Monthly Notices.'

OBSERVATIONS FOR STELLAR PARALLAX*.—In this paper Prof. Asaph Hall gives the observations with the reductions for four stars, the results being exhibited in the following table:—

Date.	Star.	Parallax.	No. of Obs.
Feb. 25, 1883, to Mar. 4, 1884.	40 (o^2) Eridani.	$+0''{\cdot}223 \pm 0''{\cdot}0201$.	30
July 31, 1883, to Apr. 15, 1886.	6 B Cygni.	$-0\ {\cdot}021 \pm 0\ {\cdot}0077$.	54
May 24, 1880, to July 2, 1881.	α Lyræ.	$+0\ {\cdot}134 \pm 0\ {\cdot}0055$.	128
Oct. 24, 1880, to Jan. 26, 1886.	61 Cygni.	$+0\ {\cdot}270 \pm 0\ {\cdot}0101$.	101

Prof. C. H. F. Peters, of the Litchfield Observatory, having pointed out that in the reduction of the observations of α Lyræ and 61 Cygni, published in Appendix I. to Washington Observations for 1879, the correction for temperature was applied with a wrong sign, Prof. Hall has reduced them (incorporating in the case of the latter star some further measurements), with the results given above. It may be remarked that Sir R. S. Ball, using one of Prof. Hall's comparison stars, has found for the parallax of 6 B Cygni the value $+0''{\cdot}482 \pm 0''{\cdot}054$. Generally Prof. Hall remarks that his observations for stellar parallax give results that are smaller than those found by other observers. This is shown most strikingly in the case of 61 Cygni, since the parallax of this star has been found by several astronomers to be very nearly $+0''{\cdot}5$.

THE NEW ALGOL-VARIABLE IN CYGNUS †.—Further observations seem to indicate that the period of this interesting object is about three days. Mr. Chandler gives the following elements for it:—1886 Dec. $9^d\ 6^h\ 22^m$ Camb. M.T. $+[2^d\ 23^h\ 56^m{\cdot}0]\,E$. From these elements the following ephemeris is derived (Washington M.T.):—Feb. $28^d\ 4^h\ 15^m$; March $3^d\ 4^h\ 11^m$, $6^d\ 4^h\ 7^m$, $9^d\ 4^h\ 3^m$.

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* Washington Observations for 1883; Appendix II.

† Gould's Astr. Journ. No. 150.

-PROBABLE NEW VARIABLE IN ANDROMEDA *.—Mr. Backhouse nds that 28 Andromedæ is probably variable within small limits nd in a short period. It is possibly of the Algol type.

MOTION OF THE LUNAR APSIDES.—We regret to notice, in the Sidereal Messenger' for February, a "paradoxical" article by r. E. Colbert on the above subject. It may possibly have been ntended for a joke; if so, it is a poor one, and the editor should ave indicated its character for the benefit of the uninitiated.

NAMES OF MINOR PLANETS.—The new Minor Planet No. 264, discovered by Prof. Peters, has been named by him Libussa. No. 256 has been named Walpurga by Herr Palisa.

THE Astronomische Nachrichten No. 2766 contains an exhaustive comparison by Dr. F. Scheiner of the star magnitudes of the 'Uranometria Argentina' (Gould), with those of the catalogues of Bessel, Argelander, Lalande, and Schjellerup.

Elements and Ephemeris of Comet 1887 *b* (*Brooks, Jan.* 22) †.

By Dr. H. OPPENHEIM.

THE following elements have been computed from observations made at Strassburg, Kiel, and Paris, on Jan. 25, 27, and 29 respectively. Parallax and aberration have been taken into account.

T=1887 March 18·8369, Berlin M.T.

$\pi - ☊$	161° 8′ 18″	Mean Eq. 1887·0.
☊	280 37 6	
i	103 51 21	
log q	0·20722	

$$\Delta\lambda \cos\beta = -2'', \text{ and } \Delta\beta = +2''.$$

Ephemeris for Berlin Midnight.

1887.	R.A. h m s	Decl. ° ′	Log Δ.	Log r.	Brightness.
Feb. 26..	3 15 58	+58 58·1	0·1317	0·2135	1·2
Mar. 2..	3 30 26	54 30·7	0·1456	0·2113	
6..	3 42 12	50 19·3	0·1613	0·2095	1·1
10..	3 52 8	46 26·5	0·1783	0·2083	1·0

The brightness at discovery is taken as unity.

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* Liverpool Astr. Soc. Circ. No. 15.

† Dun-Echt Circular, No. 135.

Elements and Ephemeris of Comet 1887 *c* (*Barnard, Jan.* 23)[*].

By Dr. H. Oppenheim.

The following elements have been derived from observations made at Harvard College on Jan. 24, at Paris, Vienna, and Padua on Jan. 29, and at Scarborough on Feb. 3. Parallax and aberration have been taken into account.

T=1886, Nov. 26·46785, Berlin M.T.

$\pi-\Omega$	30° 1′ 49″·2	Mean Eq. 1887·0.
Ω	257 48 17 ·4	
i	85 30 25 ·2	
log q	0·16398	

Ephemeris for Berlin Midnight.

1887.	R.A. h m s	Decl. ° ′	Log Δ.	Log *r*.	Bright-ness.
Feb. 26..	20 51 20	+45 44·1	0·3510	0·2872	0·69
28..	20 58 34	46 50·6			
Mar. 2..	21 5 56	47 55·6	0·3567	0·2950	0·65
4..	21 13 26	48 59·1			
6..	21 21 4	50 1·0	0·3631	0·3028	0·61
8..	21 28 50	51 1·1			
10 .	21 36 44	51 59·4	0·3700	0·3105	0·57

The brightness at discovery is taken as unity.

Elements and Ephemeris of Comet 1887 *d* (*Barnard, Feb.* 15)[†].

By Prof. L. Boss.

A new comet was discovered by Mr. E. E. Barnard, Nashville, Tennessee, on Feb. 15. The following elements are derived from observations on Feb. 16, 18, and 20.

T=1887 April 6·77, G.M.T.

π	203° 13′	Mean Eq. 1887·0.
Ω	139 16	
i	126 2	
log q	9·8892	

Ephemeris for Greenwich Midnight.

1887.	R.A. h m	Decl. ° ′	Brightness.
Feb. 28	4 16·8	+26 41	
Mar. 2	3 56·7	29 21	
4	3 40·0	31 18	0·38
6	3 26·5	+32 48	0·32

The brightness at the time of discovery is taken as unity. The comet was faint then, and is becoming rapidly fainter.

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[*] Dun-Echt Circular, No. 136.

[†] Science Observer Internat. Circ. No. 22.

ERRATA.

No. 111, p. 234, line 22, and No. 120, p. 98, line 20 from foot, *for* Borealis *read* Australis.

No. 118, p. 1, line 9 from foot, *for* − *read* +.

No. 118, p. 1, line 8 from foot, *for* + *read* −.

No. 119, p. 72, line 11 from foot, *for* sixty-fourth *read* sixty-fifth.

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Meeting of the Royal Astronomical Society on March 11 145
Meeting of the Liverpool Astronomical Society 154

Articles:—
Selenographical Notes. By Thomas Gwyn Elger, F.R.A.S. 157
Meteor Notes. By W. F. Denning, F.R.A.S. 159

Correspondence:—
The Variable Star Lal. 10063. By E. J. White, F.R.A.S. 159
The Dark Ring of Saturn. By Thomas Gwyn Elger, F.R.A.S. 161
Noises accompanying Auroræ. By Henry J. Webber 161
Aratus and Hipparchus. By W. T. Lynn, B.A., F.R.A.S. 162
Saturne—Compagnon de Sirius. By Dr. F. Terby, F.R.A.S. 163
The Colours of the Stars and the Solar Heat. By W. H. S. Monck, M.A., F.R.A.S. 164
Sir W. Herschel. By G. F. Chambers, F.R.A.S. 166
A Southern Comet. By John Tebbutt, F.R.A.S. 166
Photography and the Determination of Stellar Parallax. By A. Cowper Ranyard, M.A., F.R.A.S. 167

Notes:—
The Lick Observatory.—The Binary Star δ Equulei.—The Rousdon Observatory.—The Harvard College Observatory.—Reduction of the Places of Close Polar Stars from one Epoch to another.—Spectroscopic Method of determining the Distance of a Double Star.—Rotation Period of the Red Spot on Jupiter.—Publications of the Liverpool Astronomical Society's Observatory.—The Warner Observatory.—Prof. Bredichin on Cometary Tails.—Comets and Minor Planets.—Variations in the Sun's Diameter.—New Minor Planet.—New Red Star.—The Numerical Lunar Theory.—Editorial Notes 168-175

Ephemeris for Comet 1886 *e* (Finlay). By H. Kloock 175
Elements and Ephemeris for Comet 1887 *b* (Brooks, Jan. 22). By R. Spitaler 175
Elements and Ephemeris for Comet 1887 *d* (Barnard, Feb. 16). By Drs. J. Palisa and H. Kreutz 176

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CONTENTS OF No. 121.

Page
Anniversary Meeting of the Royal Astronomical Society on February 11 111
Meeting of the Liverpool Astronomical Society 125

Articles :—

Selenographical Notes. By Thomas Gwyn Elger, F.R.A.S. 127
The Chromosphere in 1886. By the Rev. S. J. Perry, F.R.S., F.R.A.S. 129
Meteor Notes. By W. F. Denning, F.R.A.S. 13
The Motion of a Comet when Perturbed and Resisted. By W. C. Evans, M.A., F.R.A.S. 1

Correspondence :—

Some further Notes on Binary Stars. By W. H. S. Monck, M.A., F.R.A.S. 13
Saturne—Trapèze d'Orion—Compagnon de Sirius. By Dr. F. Terby, F.R.A.S. 13
Photography and the Determination of Stellar Parallax. By the Rev. Prof. C. Pritchard, F.R.S. 13
The Argentine General Catalogue. By Lieut.-Col. G. L. Tupman, F.R.A.S. 13
The Outer Ring of Saturn: Encke's division? By N. E. Green, F.R.A.S. 13
Break-circuit Chronometers. By Prof. C. A. Young, Ph.D., For. Assoc. R.A.S. 1

Notes :—

The Six Inner Satellites of Saturn.—Total Solar Eclipse of 1886, August 29.—The Temple Observatory.—Observations for Stellar Parallax.—The new Algol-Variable in Cygnus.—Probable new Variable in Andromeda.—Motion of the Lunar Apsides.—Names of Minor Planets.—Editorial Note 140-143
Elements and Ephemeris of Comet 1887 *b* (Brooks, Jan. 22). By Dr. H. Oppenheim 143
Elements and Ephemeris of Comet 1887 *c* (Barnard, Jan. 23). By Dr. H. Oppenheim 144
Elements and Ephemeris of Comet 1887 *d* (Barnard 2, Feb. 15). By Prof. L. Boss 14

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 122. APRIL. 1887.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, March 11, 1887.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretary: E. B. Knobel.

The Minutes of the January Meeting were read and confirmed.

Mr. Knobel announced that since the last meeting 101 presents had been received; amongst them were a copy of Sir G. Airy's Numerical Lunar Theory, and photographs of a portion of Cassiopeia, of 13 Messier, and of a portion of the Orion Nebula (G.C. 1180) by the Brothers Henry.

Mr. Crossley read a paper giving a description of a new measuring rod (which was exhibited to the Meeting); also a second paper describing an apparatus for centering the mirrors of a reflector.

General Tennant. I think Mr. Crossley's idea of the complication of the ordinary way of measuring is rather excessive. As far as I know it is extremely simple except the plant. I always thought Colby's measuring-rod was a mistake. I have always held that there should be substituted some material such as glass or porcelain, which would give only a small coefficient of expansion. I very much doubt whether the so-called compensation of Colby's rod is any advantage at all. Barring that difficulty, which causes a good deal of expense for plant, I am perfectly certain the principle is sound. Mr. Crossley takes up his bar and shifts the tripod stand and puts the bar back again; but where is the security against any motion in the stand? because I do not think a clamp will hold it. It is true that for ordinary, perhaps for refined, engineering purposes a bar like this may answer; but I am quite sure you can get a much better bar, one that will answer all geodetical purposes, without materially increased expense. I wish we could see inside this bar. I have had the advantage of seeing a ving, which Mr. Crossley gave us some days ago, of this same apparatus, and I am inclined to think there are too few rollers inside, and I am not sure that these rollers are judiciously placed. Many years ago Sir G. Airy made an investigation of the number and the positions which that number of rollers should hold, in order that the length of the bar between the dots at the end should not change. I do not see there is any security in this particular case that that condition is fulfilled. As to the temperature of the bar, I do not think there is any apparatus by which you can discover it. The one security is that the coefficient of expansion is very small. I have a belief that the right way to measure a long base-line is to take a strip of aluminium in the shape of a tape, something like a steel tape or something that is extremely light; you could, I think, use that with the greatest confidence, and my belief in that is strengthened by the fact that some one in Australia has gone into the question and shown that the probable error in 600 or 700 feet of steel tape is very small; and it would, I think, be still smaller with aluminium.

Dr. Gill. I measured a base-line a month or so before I left South Africa, and one or two matters in connection with the base-line I should like to mention to prove that General Tennant's deprecatory remarks, with reference to the possibility of determining approximately the temperature of the bar, are hardly justified by facts. Beginning early in the morning, in daylight, we measured up to noon with a continually increasing temperature, and we measured backward with a continually diminishing temperature from 1 P.M. to sunset. That was as severe a trial as you could put upon the determination of the temperature by inserting thermometers whose bulbs went into wells filled with mercury. Well, I tell you that the probable error in the whole base-line of 5600 feet, computed from 8 sections of 700 feet each measured in this way, was ·015 of an inch on the whole distance of over a mile, which corresponds to a probable error of $\frac{1}{50}$th of a degree in the determination of temperature. As to the determination of the temperature in the length of the bar, the question which has been pressed by General Tennant is more in relation to the geodetical bases than the ordinary bases which are referred to in the paper under criticism.

Mr. Ranyard. I do not know that the amount of accuracy claimed follows because those two measures made by Dr. Gill in the morning and evening matched to ·01 of an inch.

Dr. Gill. These were not measures in the morning and evening, they were probable errors in the whole base of a mile.

Mr. Ranyard. Because a few sets of measures match, I do not think it follows that the probable error is *nil.* You cannot assume the whole error is caused by temperature.

Dr. Gill. Why not?

Mr. Ranyard. There are a great many other sources of error.

Dr. Gill. It would tend to increase the probable error of the whole.

Mr. Ranyard. You have a very conflicting problem in putting ese things together. You have a great many other things besides mperature to consider.

Dr. Gill. It is a fair probability to argue from such a large test this.

Mr. Crossley. I will only say a word in reply. I quite accept neral Tennant's criticism with regard to the rollers, but the nedy is to increase their number. With regard to the clamps, elieve they are exceedingly firm and as firm as you can make m. As to the temperature of the rod, I have gone on the nciple of making the rod as near as possible to the temperature the atmosphere; the small sectional area of the metal favours t. It is blackened over the surface. The small difference been the attached thermometer on the rod and that which was ttached and simply exposed to the air confirms this. I am her disposed to question the ease of getting the temperature of ng tape if it is exposed to the Sun. If you have a sky covered h clouds then, I think, you may make good measurements, but I nk you may very easily get wrong with the temperature otherwise.

Capt. Abney read a paper on the Atmospheric Transmission of ual and Photographically Active Light. He said:—In his publiion, 'Researches on Solar Heat,' which appears in the professional ers of the Signal Service, Professor S. P. Langley has been newhat hard on those astronomers who have made a speciality observing star-magnitudes. In the report on the transmissity of our atmosphere for light, in which is embodied the obserions made by his party at Mount Whitney, and which appears in above-named volume, he says "that the actual absorption *might* twice what it is customarily taken, or 40 per cent., instead of per cent., without the error being detected by such observations re now made."

n a paper which I have recently communicated to the Royal iety, on the transmission of sunlight through our atmosphere, ave described in detail observations which I have carried out ing the past year on this subject, using the visible solar spectrum the particular object I had in view. The definite conclusion ich I came to was that the loss of light followed Lord Rayleigh's for scattering by small particles—$I'=I\epsilon^{-kx\lambda^{-4}}$, where I′ and I the transmitted and original intensities, x the thickness of air, l λ the wave-length. Now, having got this result, it was easy construct curves of luminosity of the spectrum for 1, 2, 3, . . . air-thickness in which the ordinates were the relative intensi- of the rays transmitted. The areas of such curves when structed could very easily be found, and such areas would resent the total luminosity of white light coming from the Sun ugh with varying thicknesses. It would then be easy to see at variation from the law usually employed in stellar observations uld occur, and which, according to Langley, would be serious. e law in question *is that* $I'=Ia^{\sec\theta}$, I′ and I being the transmitted and original intensities and a the coefficient of transmission, θ being the zenith distance, the secant of which, within certain limits, is a measure of the air-thickness. And I found that for thicknesses of from 1 to 5 atmospheres the logarithmic formula is more than a close approximation to the truth.

Having arrived at this conclusion regarding visual observation, it struck me that absorption of the photographic spectrum ought to follow the same course. Now in the 'Proceedings of the Royal Society' I have given a very careful measurement of the photographic sensitiveness to various rays of light, besides which I had others by me, and I knew the air-thickness and the spectral luminosity on the day when these measures were taken. Assuming that the ultra-violet rays obeyed the same law as the visible rays, it was easy to calculate the photographic value of each ray for any air-thickness; and this I accordingly did, and found that the calculated and observed values agreed closely.

I have not touched upon the question of how star-magnitudes are to be measured, but merely ventured to give a means of applying a correction for loss caused by the atmospheric transmission. It appears that the loss of those rays which are photographically active is much greater than the visual rays, and it would appear that to enable a proper correction to be made to photographs of stars taken at different dates, the visual absorption at the time should also be calculated. I am not alluding now to the fact that the angle included in any star photograph is small; stars on such a plate may be compared *inter se*; but in order to make comparisons general the atmospheric absorption for the photographically active rays must be studied; and it is absolutely necessary that the spectrum value of the sensitive salt should be known beforehand.

Mr. Common. This is a most interesting subject, especially to those who are engaged in stellar photography. From what Capt. Abney says there is no doubt the total effect of the absorption of the atmosphere is the same, or similar, for all parts of the optical spectrum, whether for the photographic spectrum I could hardly gather. From one or two remarks that Capt. Abney made, it appeared that all these comparisons were made on fine days. I should like to know if he found any indication of a different absorption on other days than those fine days. I should also like to ask Capt. Abney, is it a fact or not that we may consider, for all practical purposes, that the absorption of light is proportioned, not only over the whole visual spectrum, but also the photographic spectrum?

Mr. Ranyard. I should like to ask Capt. Abney whether his observations show that we may assume that the atmosphere is colourless, and that the absorption is due to dispersion of light by small particles, which disperse a greater proportion of the light of short wave-lengths than of the long, according to the law pointed out by Lord Rayleigh, viz. that the intensity of the dispersed light varies as the inverse fourth power of the wave-length when the dispersing particles are small compared with the wave-length?

Capt. Abney. Mr. Common, I hope, will not think I am saying that absorption for every ray is the same. I only mean the integration of the rays in passing through any thickness of air will give a value which is expressed by the ordinary logarithmic formula. I do not care what the colour of the light is. I say that within the limits of five atmospheres the logarithmical formula holds. The selective scattering (I cannot call it absorption) of the rays of different wave-lengths is such that one counterbalances the other. It is the same with the photographic rays; there is a selective scattering there also. Furthermore we may go on to this, that the law in what we till recently called radiant heat still holds good. It follows to a large extent the logarithmic law. Prof. Langley's results point to something more, and I am not prepared to say that there is not something more than the logarithmic formula in certain thicknesses of the atmosphere than is found at first sight. Mr. Common has asked me about fine days. Well, you cannot see the Sun except on moderately fine days; I can see these phenomena on any day on which the Sun can be observed, and they have followed Rayleigh's law. The only time I found any variance with Rayleigh's law was when the observation was made on damp days, when there was a slight cut out in the green. That particular part of the green is where aqueous vapour or water is absorbed. The absorption which water gives lies in the green, just beyond B by *a* in the solar spectrum. These are the points where you get rain-bands. I found on damp days I did not get any green, simply because water cuts out a certain part of the spectrum. In these remarks I think I have answered Mr. Ranyard, except that I may say that the observations prove that the laws of light are not due to absorption at all (but I will modify that presently), but to the scattering by small particles, which are small compared with the wave-length. When I say I must modify that, I mean that there are two exceptions which I have found. Many of you have no doubt heard a greal deal about a green Sun; the green Sun is seen when the particles in the air are of such a size that the red rays have been scattered and the blue rays have not been scattered. Where they cut off the red rays from the spectrum and the blue ays pass through you get the green colour, and that is my expla-ation of the green Suns. It is attributable to a certain size of articles formed by natural phenomena.

General Tennant. I wish to say two things. One of the two hings is that I think Prof. Langley took a good deal of trouble get an extremely dry atmosphere. I have had a good deal of perience of quasi-dry atmospheres in India; and when the atmo-here is excessively dry you will always have a great deal of ust in suspension. There is a certain amount of damp which mediately deposits dust, and then you get a pure atmosphere. e in England, who are accustomed to a wet atmosphere that produces fog, would very likely call that a very dry atmosphere; but it is nothing approaching to the dryness you get in tropical countries. I am perfectly certain that what you want is something between the two—you want a certain amount of moisture. But there is another matter. As regards the green Sun, it so happens that two or three times in the last six months I have seen a green and a blue Sun in steam ejected from a railway-engine. I have come to the conclusion that Capt. Abney has—that there is a great deal in the size of the particles of the condensed steam.

Capt. Abney. I may say I quite agree with General Tennant about the dryness of Prof. Langley's atmosphere being detrimental to good light. My first observation of the green Sun was when I was in a train. As the steam was ejected from the locomotive the Sun appeared perfectly green, and it was then perfectly evident to me what was the cause of the green Sun which was so much talked about.

General Tennant. I am going to give the meeting this evening a sketch of a paper which will be duly printed in the 'Notices,' and which does not admit of being read out with advantage. Its object is to make known the result of sundry investigations on Parabolic Reflectors, into which I have been led by questions which have been put me by Mr. Common in connection with the large instrument which, as you no doubt all know, he is making.

In the first place I have investigated the formulæ necessary for determining the dimensions of the flat of a Newtonian or the small mirror of a Cassegrain or Gregorian, so as to give a field of a required diameter. I have shown that in a telescope of 30 feet focal length and 60 inches aperture it will be necessary, in order to obtain a field of a degree in diameter, to double the usual size of the flat in a Newtonian; and for one of 2° diameter the diameter must be nearly trebled, in order to utilize the whole speculum for all parts of the field.

I have next proceeded to deal with the focus. I have shown that for rays incident on the centre of the speculum, the focus is perfect for rays of all obliquities, and that its locus is a sphere, of which that portion of the axis which extends from the vertex to the focus of the parabola is a diameter. It follows that for telescopes of long focus, viewed either in Sir W. Herschel's way or in that which some time ago Mr. Common described as the Brachy, the image is fairly good. The field is curved, however, and the diameter of it must be small for good vision.

I have next proceeded to examine the question of the image of an object at an angular distance from the axis of the paraboloid, which axis passes through the centre of the field.

I may here deal with a point which has been put to me, and which may occur to others. As, according to my investigations, the images from one half of the speculum are so much better than from the other, would it not be possible to improve them by a stop (as in a photographic landscape lens), which shall allow only eccentrically incident rays to form the image of the obliquely seen object? In answer I would point out that the position for such a stop would be in front of the speculum, and concentric with the axis; but this place is partly occupied by the plate and its carrier, or by the flat in the Newtonian construction. Some gain will no doubt be obtained; but it will be found that when the ratio of aperture to focal length is such as very much to improve the image, the obstruction of the diaphragm and the plate-carrier together will very greatly reduce the light.

I have therefore come to the conclusion that the reflector is specially adapted for small objects. When it is desired to deal with comparatively large fields, we must look to achromatic combinations in which the power of dealing with eccentric rays is so great, and where the character of the image can to some extent be modified by selecting the curves of the lenses.

Lastly, I have deduced formulæ for the position of the image formed by different portions of a parabolic surface when the object is small, and situated at the centre of curvature for the vertex. I have carried the approximation far beyond any possible wants, even with large specula, for which such formulæ as I have seen are insufficient. I trust these formulæ may be useful in testing specula.

Mr. Knobel read a paper on the images formed by Reflectors and their Aberration, by *Lord Maclaren.*

The Astronomer Royal (who occupied the Chair for the rest of the evening in the absence of the President).—It is an interesting question we have heard discussed in the papers. It is evident that the application of photography to star-charting and similar subjects introduces quite new optical considerations which require to be properly investigated. I am sure you will return thanks to these gentlemen for the trouble they have taken in considering these important questions.

Mr. Knobel read a paper by *Mr. Roberts* on a Photographic Search for the minor planet Sappho. The planet was recognized on the plates by its motion relative to the neighbouring stars, and its position determined by measurement from these stars.

Mr. Bryant. I may say the measures referred to in the paper were not made by myself but by Col. Tupman. The reason I applied to Mr. Roberts was that we might be able to find the error of the ephemeris. The planet was discovered previously by Dr. Lohse, of Scarborough, and has also been observed on the meridian at Dunecht.

Mr. Stone was called on to read a paper on the Moon and Aldebaran; but he said there was nothing particular in the paper except that Aldebaran was not occulted at Oxford.

Mr. Knobel. I observed the occultation of Aldebaran. It was occulted with me for $9^m\ 10^s$. The only remarkable point was that the star glided out. It did not disappear instantaneously, but glided out; it reappeared instantaneously. We have a note from Mr. Elger, of Bedford, which refers to a near approach of the Moon to Aldebaran; and we have also a paper from the Rev. S. J. Johnson, who observed at Melplash Vicarage, Dorset, and he observed the occultation and gives the time of immersion and emersion. We have also a note from Mr. Prince, who observed it at Crowborough.

Mr. Turner. Mr. Lewis and myself independently observed at the reappearance that the star was bisected by some prominence on the Moon's limb, giving the appearance of a double image. The disappearance was instantaneous.

Capt. Noble. I also observed the occultation; and it is a very striking thing that there should be such a sensible parallax of the Moon at so short a distance, for my observatory is only 4½ miles from Mr. Prince's; yet at my observatory the star was behind the Moon for the best part of a minute longer than at his. When it emerged its definition was sharp. The disappearance was instantaneous and almost at the Moon's north point; and when it reappeared I could see the first diffraction-ring round the star. I never was so much impressed with the absence of an atmosphere about the Moon.

The Chairman. We have present amongst us to-night a distinguished American astronomer—Dr. Elkin. If he will give us an account of the work on which he is engaged, it will no doubt be of great interest to the Fellows of the Society. He has been working hard with the heliometer for some time past; and I shall be, I am sure, speaking the feeling of the meeting when I say we shall be glad to hear an account of his observations.

Dr. Elkin. I have not quite finished all my work that I intend to do, and on which I have been engaged during the past three years; but a portion of it I have finished, and that portion is with reference to the group of the Pleiades, which I took up for the first piece of work. I suppose you will remember that Bessel with his heliometer took measurements of the Pleiades; and it is of some interest to repeat the observations by the same method. I will not trouble you with any details, but perhaps a point of some general interest will be with regard to the internal motions of the group. The motions are very small. I found I had to single out from all the stars those which do not belong to the cluster. If you take any portion of the sky you will find a certain number of stars; and here we have a great number, and probably some belong to the group and some do not. I think I have, by means of the motion, singled out those that do not. That is by knowing the absolute motion of the group deduced from the Greenwich observations. Thus η Tauri moves about 5″ in a century. Among the 52 stars which I have taken from Bessel, there are six of which the motions apparently are just exactly in the reverse direction or nearly so, as if they would be left behind by the group. Those six belong to the faintest class, and they are all scattered about the group in different positions, exactly as if they do not belong to the group, so I think there is a chance of their not belonging to the group. Now if we take the number of stars in the sky down to the 9·2 magnitude, and divide that by the number of square degrees, it will come to 7 or 8 per square degree. You would expect to find 7 or 8 stars on any part of the sky in that area, and here we have six stars apparently not belonging to the group; so I think it is not improbable that these do not belong to the group, so that these will be the six stars to compare with the others. I do not think I will trouble you with any more details about the Pleiades. The work is nearly finished and it is going through the press, and will come to the Society in the course of time. Since then I have taken up some stellar parallax work. It has been carried on for the last year and a half, and will be carried on for another year still. I am taking a little holiday of six weeks, and when I get back I shall probably carry it on for another year. We have commenced on the system which Dr. Gill outlined in his paper to the Society, which was published two years ago—that is, taking a number of stars of each magnitude and trying to find out their mean parallaxes; and I have started, of course, by taking the brightest, and I have chosen the ten brightest stars in the northern hemisphere. Those I propose to observe from twenty to thirty times each. We cannot expect to get a very accurate value of the parallaxes with so few observations; but when we have 300 or 400 observations of the ten stars they will give, I think, probably the mean value of the parallaxes of the ten stars; and you may possibly have some knowledge of the mean parallaxes of the 1st magnitude stars. I cannot tell you any definite results as to the parallaxes, because they are not finished. (Applause.)

The Chairman. You have anticipated me in returning thanks to Dr. Elkin for the very interesting communication he has made to the Society. It is a most important result, I think, which he has shadowed forth here about the Pleiades, because, by saying that there are six or seven stars which do not belong to the group, he implies that all the other stars are connected together. That in itself is a very interesting conclusion, independently of his indicating the means by which the parallax of the group may be determined.

The following papers were also announced:—

W. S. Franks. "A proposed Nomenclature for Star-colours."

J. E. Gore. "Observations of the Variable Star S (10) Sagittæ."

Royal Observatory, Cape of Good Hope. "Observations of Comets made in the year 1886."

G. F. Chambers. "A working Catalogue of Red Stars."

C. L. Prince. "Occultation of Aldebaran, 1887 March 2."

W. H. Finlay. "Elements of Comet 1886 *e* (Finlay)."

W. H. Finlay. "Comet 1887 *a*."

Rev. S. J. Johnson. "Second Occultation of Aldebaran, 1887."

T. G. Elger. "Note on the near Approach of the Moon to α Tauri, 1887 March 2."

John Tebbutt. "Observations of Winnecke's Comet, 1886, made at Windsor, New South Wales."

Royal Observatory, Greenwich. "Observations of Comets *e* 1886 (Finlay), *b* 1887 (Brooks), *c* 1887 (Barnard), and *d* 1887 (Barnard)."

C. Todd. "Observations of Comet *a* 1887 made at the Observatory, Adelaide" (extracts from letters to the Astronomer Royal).

The Meeting adjourned at $10^{\mathrm{h}}\ 0^{\mathrm{m}}$ P.M.

Liverpool Astronomical Society.

THE sixth meeting of the Session was held on Monday evening, the 14th March. Mr. W. D. H. Deane, M.A., occupied the chair. The election of 23 members was confirmed, and 10 candidates were nominated.

It was proposed by Mr. Thos. Gwyn Elger, F.R.A.S., that the Annual General Meeting be this year held in London. The society, though nominally associated with the city of Liverpool, had assumed a national character, inasmuch as it included members from all parts of Great Britain and Ireland, and, consequently, ceased in any way to remain a local institution. For the future welfare of a society constituted on this basis, it was desirable that an annual conference of members be held at some place conveniently situated for such an assembly. A large proportion of members resided within a radius of 80 miles from the metropolis, and it was in every way desirable that the Annual Meeting for 1887 be held there.

Mr. C. A. Defieux seconded, and he was sure it would receive the support of all local members. [Applause.] The annual meetings had hitherto been anything but representative. A few members had met in a friendly way to pass the accounts, and after a few mutual compliments, the annual meeting of that year was a thing of the past. No doubt all this was very pleasant; but it tended to make things run too much in one groove, and a little outside criticism would be beneficial in every way.

Mr. S. M. Baird Gemmill opposed the resolution. He thought it would be quite out of keeping for the Annual General Meeting of the *Liverpool* Astronomical Society to be held in *London*. It could not promote the intercourse of members, since it would be only those residing in the metropolis who would benefit. He thought it would be detrimental to the Society to do anything which could in any way interfere with the continuity of its history. The imaginary difficulty of its being supposed to be a mere local affair had not prevented its rising in the past, and certainly would not do so in the future.

Mr. James Gill, a vice-president, heartily supported the resolution. Whatever benefit there was ought to be shared equally, and London had certainly the first claim. It was impossible for non-residents to appreciate the difficulties presented by the supposition that it was a mere local affair, or they would see they were far from imaginary.

Mr. Walter Sang thought it might be as well next session to hold ordinary meetings in different towns, on the lines of the British Association, the preference to be given to those towns which contained most members.

A paper was read on the absolute dimensions of a star-cluster by Mr. J. E. Gore. The globular star-clusters, consisting of thousands of minute stars, were some of the most interesting objects. It was not easy to understand on what dynamical principles such an immense assemblage of bodies could exist without interfering with each other. They could not be at rest, and it was possible that each of the components described an ellipse about the centre of gravity, which would probably be situated near the centre of the sphere. One of the most remarkable of these objects was 13 Messier, which lay between η and ζ Herculis. The number of stars in this cluster was estimated by Sir W. Herschel at 14,000, and Admiral Smyth stated that its central condensation must be subject to no known law of aggregation. This might convey the impression that the component stars near the centre were almost in contact. If, however, they considered the cluster as a sphere filled with stars, the apparent condensation at the centre was easily accounted for. Mr. Proctor was of opinion that the whole cluster need not exceed in mass an average 1st-magnitude star. If they assumed the total mass as equal to twice the Sun's, it would give an average diameter of 45,218 miles for each component; and a very simple calculation on the above assumption would show that so far from the closeness of their positions being real, each star in this wonderful cluster might be separated from the next by a distance of 9000 million miles!

In a second series of the micrometrical measures of 25 double stars, Mr. K. J. Tarrant acknowledged the valuable assistance he had received from Mr. Herbert Sadler. His experiences during the measurement of τ Cygni formed an interesting example of the liability to error in this class of observation. In a former measure he had given the distance of this pair as 1″·08; but though it had since been regularly observed, it had only been noted as single. It seemed quite impossible that it could have closed up in one year, so it at once led to the conclusion that the object he had measured in 1885 must have been a spurious image. This was corroborated by the observations of Prof. C. A. Young with the Princeton refractor of 23 in., and by Prof. Asaph Hall with the 26-in. refractor at Washington. From their observations the distance must have been 0″·60, which, from the inequality of the components, would be too small to detect with his aperture. This pair, although now beyond the reach of any but very large apertures, was a most interesting object, as later measures proved the distance to have since decreased to 0″·40, which gave a period of less than 50 years, probably one of the shortest in the northern hemisphere.

In a paper on the temperature of stars, Mr. W. H. S. Monck included all bodies in space, whether luminous or not. That there were dark bodies in stellar space the existence of meteors afforded conclusive proof, since many of them described parabolic, or even hyperbolic, orbits. Again, there was a class of variables known as the Algol type, which strongly suggested the periodical transit of a dark satellite across the face. Further, the immense body of telescopic stars offered strong indications, either that the entire stellar system was confined within a measurable distance from the solar system, or that the light was absorbed by some medium. The great difference in the mass of known bodies confirmed this conclusion, as from Jupiter downwards the scale was regularly progressive. Some of the asteroids were very small, and the satellites of Mars still smaller, whilst recent observations went far to prove that the zodiacal light and the rings of Saturn were but the concentrated reflection from very small bodies indeed. There were also other grounds for extending these conclusions beyond the limits of the solar system. The masses of several binary stars had been determined, and these differed very considerably from each other. Now, a difference in size meant a corresponding inequality of temperature, and consequently of light; for it was evident that small bodies would cool much quicker than larger ones, and there was no reason for supposing a greater initial temperature. A remarkable instance occurred in the case of Sirius and its satellite, for, if they could rely upon the computations of their masses, the satellite was only one half the size of its primary. The relative disparity of their brilliancy was still more conspicuous, for the satellite was fully 12 magnitudes below Sirius in the usual scale. Assuming, then, that both bodies were spheres of equal density, Sirius gave one thousand times the light of its companion for each unit of surface. Spectroscopic evidence would tend to the same conclusion; for they knew from practical experiment that the more highly a body was heated, the more its spectrum was developed at the violet end, and such differences in stellar spectra might reasonably be referred to the effects of temperature.

Capt. W. Noble contributed a note of his observations made during the recent occultation of Aldebaran. The star had disappeared, almost at the true north point of the Moon's limb, absolutely instantaneously. Its reappearance at the bright limb was a beautiful sight, as it flashed into view in a valley among a small range of mountains; and so exquisite was the definition of its disk, that the first diffraction-ring was visible in contact with the limb of the Moon, a conclusive proof to him of the non-existence of any lunar atmosphere whatever. The pronounced orange tint of the star was very apparent as contrasted with the silvery light of the Moon. Nothing in the slightest degree resembling projection or clinging to the Moon's limb was apparent. As the Society had an educational branch, he would call attention to the marked difference in the duration of the occultation, which was caused by relatively minute displacement on the Earth's surface. His observatory was situated not quite 32 miles from Greenwich; but this relatively small distance made a difference of $7^m\ 7^s$ in the duration of the time of occultation; whilst at the Crowborough Observatory, which was only $4\frac{1}{2}$ miles to the N.E. of his own, there was a difference in duration of $1^m\ 27^s$.

Mr. T. G. Elger continued his description of the Moon's surface by an account of Petavius. This was one of the formations which might profitably be studied with even a 2-inch telescope, and was entitled to rank as one of the most important lunar formations.

Mr. A. J. Whalley suggested the delineation of the lunar features on a large scale. This would avoid the difficulty of representing minute details, often in a very inconvenient position at the telescope. The sketch might afterwards be reproduced on a smaller scale. Large charcoal sketches of Copernicus and of some Sunspots were handed round for inspection, together with photographs of the same pictures on a much reduced scale.

In a continuation of his articles on telescopic work, Mr. W. F. Denning treated on Method, and on a persistent enthusiasm in observation. Nearly all the most successful observers had been men of method, and recognized a certain purpose in every observation. He deprecated the too common practice of amateurs in looking up an object for the simple satisfaction of seeing it.

Papers were received from Mr. S. M. Baird Gemmill on Suspected Variable Stars; on Shickard, a lunar formation, by Mr. C. M. Gaudibert; and on Quelques considérations sur l'étude des étoiles doubles, by Monsieur B. Lihou.

The Meeting adjourned at 9.30 P.M.

Selenographical Notes.

THE REGION SURROUNDING HERSCHEL. UNRECORDED RILL THROUGH PTOLEMÄUS.—The rough mountainous district bordering Ptolemäus on the south, and extending northwards to the Sinus Medii, was admirably seen on the night of March 2nd, when the morning terminator just grazed the eastern border of the great walled plain. Between 8^h and 10^h the definition was so exceptionally steady that even with a power of 384 on my $8\frac{1}{2}$-in. Calver reflector minute details came out with a sharpness and freedom from tremor which is unfortunately very rarely experienced. At this stage of illumination the interior of the circular ring-plain Herschel is wholly in shadow, as is also the oblong-shaped crater on the south wall. The shallow formation, *a*, standing on a wide tableland on the north of Herschel, was fully illuminated with the exception of a narrow serrated band of shadow due to its low west wall, but though Neison speaks of a small central mountain no such object could be detected on its apparently level interior. The well-known deep valley, *e*, classed by Schmidt among the rills (S. 319), borders Herschel and the tableland on the west, and beyond this lies a large grey enclosed plain, *h*, at the north-west corner of which stands the conspicuous crater Réaumur *b*. From the south wall of this latter object a spur projects which, continuing southwards, forms the western border of the plain. While examining this enclosure for detail I became aware of the existence of a very delicate rill which crosses it from north-west to south-east, and runs up to a minute crater (shown by Schmidt) on the eastern side of the enclosure near the western edge of the great valley *e*. After a moment's examination of this object I found that it extended on the east side of the valley, crossing an apparently level region, and, traversing the rocky margin of Ptolemäus, passed on to the floor, ultimately terminating at a small crater near the north-east side of the formation. It is certainly one of the most delicate objects of its class that I have met with. At times of best definition it resembled, both as regards fineness and directness, the thinnest possible line that one can imagine it possible to trace with a straight-edge and drawing-pen. On the floor of Ptolemäus it runs between the shallow crater *d* and the north-east wall of the formation, but much nearer the latter. On 22 April, 1885, M. Gaudibert suspected the existence of a rill running across Ptolemäus from the north side of the large depression *b* to a craterlet south of *d*. I am able to confirm this observation, his rill being a comparatively easy object running nearly parallel to that which is here recorded. It is probable that both these clefts extend to the eastern side of the walled-plain and join the curious crater-rill shown by Schmidt. On the evening of March 2nd the remarkable crater-row on the south-west wall of Herschel was a very noteworthy feature. It appears to consist of seven distinct depressions arranged in a line concentric with the margin of the ring.

RILL NEAR PARRY A.—Between 7^h 30^m and 9^h 0^m on the evening of March 3rd, the east longitude of the morning terminator being about 17° and the definition very favourable, a delicate rill was traced from the foot of the north border of Parry A to the east side of the curious hook-shaped formation lying south-west of Parry and partly connected with this walled-plain, marked μ in Neison's Map XIII. There is a lofty peak on the southern end of this object which, at the time of observation, threw a prominent shadow towards the north side of Parry A, and the rill was followed westwards to its apex. A low ridge running up to the crater from the south wall of Parry crosses the cleft near its apparent origin. The great rill east of Parry A, and its northerly extension through Parry and Fra Mauro, was very prominent. The small crater nearly central on the floor of Parry appears to stand on a slight elevation.

Kempston, Beds., 1887, March 19. **Thos. Gwyn Elger.**

Meteor Notes.

The Lyrids of April 18–20.—With favourable weather these meteors ought to be well observed this year, as there will be no interference from moonlight. As seen from Bristol in 1884 on April 19, the shower furnished about 22 meteors per hour for one observer *. In 1885 there were only 3 per hour, and the display seemed pretty equally distributed over the three nights of the 18th, 19th, and 20th. The most important result obtained in the latter year was the rapid displacement of the radiant-point amongst the stars of Hercules and Lyra †. On the 18th this point was at 260° +33½°, 19th 267½° +33°, and 20th 274° +33½°.

Aquariads of April 29–*May* 6.—This stream (conjectured to be associated with Halley's comet) should be looked for in the eastern quarter, just before daylight, but the Moon comes into the morning sky after May 1. Observations should, however, be obtained until May 6th, as the maximum of the shower occurred on this date in 1886. The radiant-point is slightly south of the equator, and Col. Tupman determined it at 326½° R.A.; but there is strong reason to believe the real position is fully 10° east of this, or at 337° ‡.

Recent Observations.—Only 29 meteors were observed at Bristol during February, chiefly on the 10th, 12th, 21st, and 26th, and these were insufficient to denote any well-defined radiants. On Feb. 10 at 7^h 31^m a beautiful 1st-mag. meteor was seen moving very slowly from 103° +58° to 165° +46½°, path 38° long. It left a thick train of sparks, colour yellowish white. Duration 7½ seconds; probable radiant at 32° +17°, S.E. of α Arietis, and identical with that of the large slow-moving fireball of Nov. 17, 1886.

Bristol, 1887, Mar. 19. **W. F. Denning.**

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Variable Star Lal. 10063.

Gentlemen,—

As the statement of the variability of this star has excited considerable interest, and as Mr. Sawyer, in his letter contained in the December number of the 'Observatory,' has expressed dissatisfaction with the conditions under which the observations were made, I forward you a fuller account than is supplied by Mr. Ellery's letter which appeared in the 'Observatory' of last October. On May 31, 1886, about two hours after sunset, I obtained a set of measures, with our north equatorial, the telescope of which has an aperture of 4½ inches, between Barnard's comet and a 9th mag. star; seeing some clouds rising, and being anxious to resume my meridian work, I, for the purpose of identification, compared this 9th mag. star with the brightest star I could see in the neighbourhood with my naked eye. The star was about 10 degrees high at the time, and in the telescope I estimated it as being of the 4th magnitude. The next morning I searched in the B.A.C., and was surprised at not finding the star therein, and concluded that, if no mistake had been made in the measures, it was not contained in any of the catalogues from which the B.A.C. is compiled, or, if it were to be found in them, that it must have been registered as fainter than the 6th magnitude. I failed also to find it in Yarnall and Oeltzen; as the latter work contains Argelander's zones, where most of the stars down to the 9th mag. are recorded, I was fortified in my opinion that this star must occasionally become very faint. The first record I could find of it was in the B.A. Lalande, where it appears as No. 10063, and of the 5½ mag. I drew Mr. Ellery's attention to the matter, and on the next evening at sunset we set the instrument and saw the star in the middle of the finder shining very brightly, and we both exclaimed that it was a good 4th; we then brought the star and β Leporis successively into the field of the telescope, and estimated them to be of equal magnitude. On setting the instrument to the mean place between the two stars, they were both seen at the same time in the finder, which has an aperture of 1¾ inches, and although they were near the edge of the field, it was easy to compare them, and no difference could be detected in their brightness. It had now become sufficiently dark to see them with the naked eye, and we still classed them as equal. On the evening of 4th I looked out for it while the Sun was shining brightly, about five minutes before sunset; it was found at once, compared with β Leporis, and estimated to be equal to it. On the 5th it was observed about an hour after sunset; it had sensibly diminished in brightness, and was considered little brighter than the 5th mag. On the 9th it was seen just after sunset and was still estimated a good 5th. On the 14th I did not consider it brighter than a 6th, but on the 26th I reckoned it 4½ mag. After this the star was too near the Sun to be well seen in the evening, and I did not again observe it till Nov. 22nd, when I called it in the 6th mag. and noted that the light was of a reddish colour. A couple of evenings ago it was observed on the meridian, and estimated to be of the 5th mag., the observer also noting the reddish colour. I have no doubt that this star will now be narrowly watched; at the same time it is beyond dispute that at the beginning of last June it was shining with much more than its usual brilliancy.

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* 'Observatory,' vol. vii. (Aug. 1884), pp. 217–20.

† 'Nature,' May 7, 1885, p. 5.

‡ 'Monthly Notices R.A.S.,' May 1886, pp. 396–8.

I am faithfully yours,

E. J. White.

Melbourne Observatory,
1887, Jan. 21.

The Dark Ring of Saturn.

Gentlemen,—

In his interesting communication in the March issue of the 'Observatory,' Dr. Terby speaks of the obscure ring as appearing, on Dec. 25, 1886, separated from B by a space as black as, and probably broader than the Cassini division. During the favourable observing weather we have enjoyed of late, anomalies were remarked here in connection with this object which, with your permission, I should like to place on record. On February 25, though the *f* ansa of the dark ring was very dusky, it was perfectly distinguishable, while the *p* ansa was noted as unequally dark, certain parts of its surface appearing quite black. On the following night, with excellent definition, the *p* ansa exhibited on its inner margin three or four large re-entering angles, like the teeth of a saw, the space between this jagged outline and the ball being perfectly black. On February 27 and 28, also favourable nights, I was unable to distinguish the appearance observed on the 26th, though the *p* ansa was evidently unequally dark and patchy, as on the 25th. Observations on March 12, 13, and 16 confirm the anomalous appearance of the surface of the *p* ansa. On March 18, between 9^h and 10^h (with a superb image of the planet, showing Encke's division as a hair-line on the ansæ of ring A), the *f* ansa of the obscure ring was a sombre but easy object, while the *p* ansa again exhibited a serrated border, and was apparently separated from B, on the *s.p.* side, by a wide ill-defined black space. In these observations I used powers of 350 and 384 on my 8½-in. Calver reflector. Though only just aware of the fact, I find that Capt. Jacob described on one occasion, some 35 years ago, the inner edge of the crape-ring as scalloped "like the fold of a curtain."

Yours truly,

Thomas Gwyn Elger.

Kempston, Beds, 1887, March 21.

Noises accompanying Auroræ.

Gentlemen,—

I have just been reading an article, in Cassell's 'Science for All,' on the "Northern Lights," by Geo. Wm. von Tunzelmann, in which he says "It is at present rather doubtful whether the auroral displays are or are not accompanied by any sound. Many observers have asserted that during an aurora they have heard crackling and hissing sounds; and some experiments made by M. Planté, to which we shall presently recur, as they throw great light on the theory of the aurora, decidedly support this view. On the other hand, some of the most eminent polar explorers (among others, Sir Geo. Nares and his companions) have listened in vain for these sounds, and have given it as their opinion that what was heard was merely the breaking-up of the ice, and the grinding of the icebergs."

Until I read this article I was not aware of there being any contention among scientific men respecting those sounds. I think it will be of interest to your readers if I place on record an experience of my own. I have made several voyages to Canada, and I have had the good fortune to see some brilliant displays in the Gulf and River St. Lawrence. One in particular was very remarkable and perhaps phenomenal. We lay at anchor midway between Quebec and Montreal. It was a lovely summer's night, very calm and remarkably quiet, and we witnessed an auroral display in its full splendour. Nearly the whole of the sky, from the horizon to the zenith, was covered by it—enormous streamers were being continuously shot out, *and were accompanied by a sharp crackling sound*, very similar to that which is caused by certain powerful electric experiments. The sound was *by no means subdued*; but I cannot say it was absolutely loud, for it might give one an exaggerated idea of it. The display lasted several hours, and was at *a very short distance from the earth*. Mr. Tunzelmann says, "There is still another phenomenon connected with the polar lights, viz. the abundant falls of rain or snow which have always been noticed during the prevalence of an aurora." I may state that neither this display nor the others I have witnessed were preceded or followed by rain. Being unaware of the importance of it, I did not record it in my note-book; but I fancy it took place on July 31, 1883. On that occasion I was on board the S.S. 'Scotland,' owned by Temperleys, Carter, and Darke, 21 Billiter Street, to whom I am well known. It is, of course, important to have a report like this verified; but this will take me a long time to do, as I learn that the officers are scattered and are all at sea. I may state that I am well known in the chess world, having been an old and active member of the City of London Chess Club, and I am an honorary member of the Birkbeck Institution.

Yours respectfully,
HENRY J. WEBBER.

8 Arundel Terrace,
Dover Road, Gravesend; and
34 Arundel St., Strand,
Feb. 24, 1887.

Aratus and Hipparchus.

GENTLEMEN,—

In the third number (for January last) of the 'Babylonian and Oriental Record,' Mr. Robert Brown, Jun., F.S.A., points out that a mass of evidence has of late years been accumulating which tends to show that the ancient constellations are of Babylonian origin, and came to Greece through Asia Minor. He then touches upon part of the description of the constellations versified in the *Phænomena* of Aratus, and the criticisms of Hipparchus upon this. His view is that the real reason why the positions of the zodiacal constellations (instancing particularly Aries) do not agree, as Hipparchus noticed, with the heavens, is that Aratus was, in fact, describing the positions as laid down by Babylonian observers about two thousand years before his own time, and that the disagreement was the effect of precession.

Now it will be remembered that Delambre pretty fully discussed the question whether the description of the zodiacal constellations in Aratus agrees better with the positions they occupied with respect to the celestial equator many centuries before his own time. He considered that it was impossible to come to any decided conclusion on the point; so that if other investigations show that the constellations are really of Babylonian origin, there is no reason why this should not be accepted, though, on the other hand, it can hardly be said that the points mentioned by Mr. Brown afford any confirmation of it. Many, indeed, of the criticisms of Hipparchus have no reference to the positions of the constellations with regard to the equator nor any connection with the effects of precession.

But there is one point not mentioned by Mr. Brown on which I should like to say a few words.

Hipparchus finds fault with Eudoxus (of whose lost work on the constellations that of Aratus is understood to be principally a versification) for stating that there is a star in the celestial pole, and says that this is not the case, but that there are three stars which form a sort of square with the place of the pole. (For this he appeals to the observations of Pytheas of Marseilles, whose voyage along the eastern coast of Britain and across the North Sea to the Norwegian coast is now generally admitted to be historical, notwithstanding the doubts of Strabo and others.) Now Delambre identifies these three stars as β Ursæ Minoris, α and κ Draconis, but draws no other inference from the remark of Hipparchus, apparently thinking that the star stated by Eudoxus to be in the pole was one of the very small stars situated in the nose of the modern constellation Camelopardus. But surely it is a more probable view that we have in this a rather striking confirmation of the theory that Aratus is describing the state of things as handed down from about two thousand years before his own time, when α Draconis occupied a position nearly in the pole.

Blackheath, 1887, Feb. 27.

Yours faithfully,
W. T. Lynn.

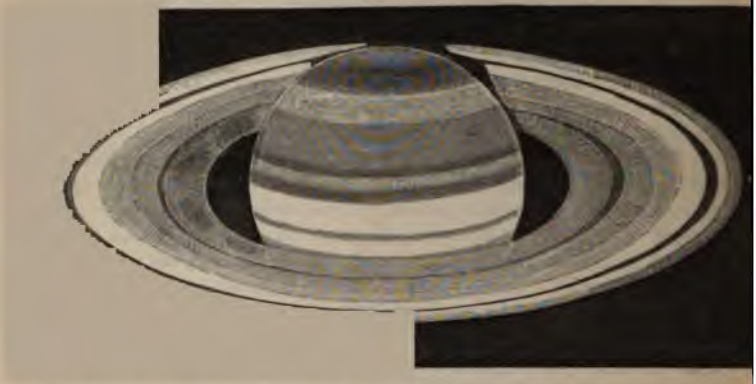
Saturne—Compagnon de Sirius.

Messieurs,—

J'ai le plaisir de vous envoyer un dessin de Saturne fait d'après mes observations à l'équatorial de 8 pouces de Grubb (réfracteur), avec des grossissements compris entre 150 et 650 fois, en février 1887. Je serais bien heureux si vous pouviez le reproduire dans l'*Observatory*. Ce dessin montre notamment:

La division d'Encke, le trait brillant de MM. Henry, dans

l'anneau A, contre la division Cassinienne, la division de Struve, entre les anneaux B et C, surtout à l'orient, des masses sombres dans l'anneau obscur, surtout à l'occident, la dentelure de l'ombre du globe sur la division Cassinienne, à l'orient; une dentelure grise isolée, également sur la division Cassinienne, à l'occident; l'ombre du globe sur l'anneau obscur; la transparence de l'anneau obscur qui laisse voir le globe au travers de sa substance.



Dans ma dernière lettre, je vous annonçais que je voyais le compagnon de Sirius ; j'ai réussi, en effet, très bien, à voir le petit astre en pleine nuit ou pendant le clair de lune en cachant l'étoile principale avec un fil placé dans l'oculaire grossissant 150 fois ; aussitôt que ce fil *touche* Sirius le compagnon apparaît. Je crois pouvoir assurer aussi avoir vu le compagnon pendant le crépuscule, sans fil occultateur, mais je dois renouveler mes essais dans de meilleures conditions, et j'aurai le plaisir de vous en faire connaître les résultats.

Votre bien dévoué,
Dr. F. Terby.

Louvain, 12 mars, 1887.

The Colours of the Stars and the Solar Heat.

Gentlemen,—

While I agree with Mr. Lynn in thinking that the evidence for a change of colour in Sirius should not be rated too high, there are other stars in which a similar change appears to have occurred within historic times, and the alteration seems usually to have been in the opposite direction from that which secular cooling might be expected to effect; this fact was noticed in a paper recently read before the Liverpool Astronomical Society by the Rev. T. E. Espin, and since published in the Society's Journal. It seems to me that a possible explanation of the facts may be afforded by supposing the stars in question to have been surrounded by an absorptive

atmosphere, which is gradually becoming condensed in the process of cooling. Observations on the comparative energy of the central portion of the Sun and the parts situated near the edges seem to have clearly established the presence of such an absorptive atmosphere in the case of the Sun; and as the light and photographic power diminishes more rapidly than the heat as we approach the edge, there can be little doubt that this atmosphere permits red light to pass more freely than other kinds of light, and that its presence not merely diminishes the total light of the Sun, but gives to the ruler of our system a redder hue than it would otherwise possess. The light radiated by any body no doubt becomes redder as the body cools; but if this cooling is accompanied by the condensation of an absorptive atmosphere, the light which passes through that atmosphere, and reaches the Earth, may become whiter as the cooling process goes on. The colour of the Sun or star would in this instance appear to indicate increased heat when the reverse process was really in progress. And a similar observation would apply to the quantity of heat received from it. As the cooling went on, the amount of heat radiated would necessarily diminish, since the radiating surface would be contracted, and the heat radiated from each surface-unit would also be lessened in consequence of its lowered temperature. But if a large proportion of the heat originally radiated was absorbed by the stellar atmosphere, and much of it conveyed back again to the star, it is evident that the condensation of this atmosphere might enable the star to give more heat to the surrounding bodies when its own temperature was steadily diminishing. And this may be the reason why no great diminution of solar heat appears to have taken place since the earlier geological ages. The Sun may have been steadily cooling and giving out less and less heat during the entire period; but the gradual condensation of its absorptive atmosphere may have enabled a larger proportion of its radiant heat to reach the Earth, so that the terrestrial climate has suffered but little alteration. A check in the condensing process while the cooling went on might produce a Glacial Period, while a period of unusual warmth might be consequent on a very rapid condensation of the absorbing atmosphere.

May I add that the names of the stars of the first magnitude at present in use in our hemisphere appear to have been selected with a view to their colours, the order being alphabetical, commencing with red and ending with blue. Omitting Al Tair (which may have been regarded as commencing with T), the order stands thus:—Aldebaran, Antares, Arcturus, Betelgeuse, Capella, Procyon, Regulus, Rigel, Sirius, Spica, Wega. As these names are of different origin and did not originate at the same time, however, the intimation of colouring thus afforded cannot be carried back to the remote past.

I remain, truly yours,

W. H. S. Monck.

Sir W. Herschel.

Gentlemen,—

In the newly published 'Court and Private Life in the Time of Queen Charlotte,' by Mrs. Papendiek (Bentley, London), there will be found an extremely interesting account of Sir W. Herschel's early labours at Slough, beginning with the actual taking possession of the house and premises which afterwards became so famous. As Mrs. Papendiek was the tenant who immediately preceded Herschel in his tenancy, her account of the circumstances comes to us at first hand and in the most authoritative form possible. The passage contains information concerning the reasons which brought Herschel to England, which are new to me; concerning his life at Bath and generally. The account occupies five 8vo pages (vol. i. pp. 251–255), and might be reproduced with advantage in your pages.

Your obedient Servant,

Eastbourne, 1887, Mar. 9. G. F. Chambers.

A Southern Comet.

Gentlemen,—

The tail of a large comet was announced in the Colonial newspapers to have been seen from several places in the neighbouring colonies on the evening of January 20th. Its position was on the south-west horizon, but nothing could be seen of the nucleus. Cloudy and rainy weather prevailed at Windsor for many days, and it was not till the evening of the 28th that I was afforded an opportunity for observing the stranger. As soon as it was thoroughly dark the tail could be faintly seen extending over many degrees; and I noticed at its lower or brighter extremity a star of the fifth magnitude, which, although it was not apparently surrounded as usual by nebulosity, I at first took to be the nucleus. On pointing the 4½-inch equatoreal to the object I saw immediately that the supposed nucleus was really a fixed star, afterwards identified as σ Phœnicis. Although the lower extremity of the cometary ray or beam was certainly in the immediate neighbourhood of this star, I could not, after a careful search, find the slightest condensation for observation. The tail, which was straight, extended as far as Achernar, the extremity of its axis lying about half a degree south of that star. The next evening was cloudy; but on the 30th the tail was again seen, but not till the Moon had reached the horizon. It was even then excessively faint, its lower extremity being close to λ Phœnicis, which at first sight might have been taken as the nucleus. My search for a nucleus or even the slightest condensation as a point for observation was again quite unsuccessful. The upper extremity of the tail on this occasion lay between the stars q^1 and q^2 Eridani. The evening of the 31st was cloudy, and on Feb. 1st, although the sky was pretty free from cloud, not the slightest trace of the tail could be seen owing to the brilliancy of the Moon. There is not the faintest hope of seeing the comet again. I trust that observers in other parts of the southern hemisphere have been more successful, for I fear our Australian observations will prove to be little better than those made by the primitive Chinese astronomers.

Windsor, N.S. Wales,
1887, Feb. 6.

Yours faithfully,
JOHN TEBBUTT.

Photography and the Determination of Stellar Parallax.

GENTLEMEN,—

Prof. Pritchard's description of the photographic image of a star seen with a magnifying-power of 20 diameters, as being a "very definite hard black circular dot," with "a slight fringe of discreet dots visible round it," differs from the description I should give of the stellar images I have examined. To me they appear as a granulated patch without any definite well-defined edge. The rate at which the photographic action decreases in passing from the centre of the stellar image outwards differs with the optical qualities of the instrument with which the photograph has been taken, as was shown in a paper I wrote several years ago in conjunction with Lord Crawford; and with the same instrument the size of the granulation into which the image of a large star is broken up varies greatly, according to the photographic process and method of development employed. With a small star and an instrument giving a sharply defined image, the region of the first commencement of photographic action is very small when the instrument is steady and the night still; but I should not in any case describe it as having anything like a definite hard edge. It is possible, however, that I misunderstand Prof. Pritchard, and that the central dot he speaks of is a single element of the granulation, which he selects as the darkest central element. If so, its centre will not necessarily correspond with the centre of brightness of the stellar image. Whether he adopts Capt. Abney's theory that the granulation is due to a crystallization or aggregation of particles of altered silver within the film, or whether he adopts the theory which I have advocated that the granulation is due to the unequal contraction of the surface and the deeper parts of the film in drying, it is evident that the position of the individual granules will be determined by inequalities in the film or in the matter suspended in the film; and it is improbable that the centre of the densest granule will coincide with the centre of the illuminated patch representing a star. It is the position of the centres of illumination which must be determined for parallax purposes.

When the position of a large star relatively to small ones has to be measured, there will always be the difficulty of determining the true centre of a large granulated patch, until photographic methods are adopted for astronomical photography which give rise to little or no granulation. The Brothers Henry have made a great advance in this direction; the granulation of their recent plates is much finer than that of the dry plates we have been using in England; and I trust that in the future the difficulties arising from granulation may be entirely overcome.

Yours &c.,

1887, Mar. 22. A. COWPER RANYARD.

NOTES.

THE LICK OBSERVATORY.—The 'Sidereal Messenger' states that Prof. Holden has nominated Messrs. Burnham, of Chicago, and J. E. Keeler, assistant to Prof. Langley, for assistants at the Lick Observatory. The appointment rests with the Board of Regents. Should Mr. Burnham be appointed, we may expect a revision of his double-star catalogues. While on the subject of the Lick Observatory it may be interesting to some of our readers to know how the great object-glass was packed for transmission from the Clarks to Mt. Hamilton. The lenses were packed separately in 15 or 20 thicknesses of soft, clean, cotton cloth; next came a thick layer of cotton and then a layer of paper. These packages were then put into wooden boxes lined with felt. No nails were used near the glasses, and the boxes were made the shape of the glasses. These boxes were next enclosed in two others of steel and packed tightly with curled hair. Each steel box was enclosed in another steel box, the insides of which were covered with spiral springs. Both steel boxes were air-tight and water-proof, and the outer chests packed with asbestos to render them fire-proof. Each was then suspended by pivots in strong wooden frames with contrivances for turning each chest one quarter round every day during the journey to California. This is to prevent any molecular disarrangement in the glasses and to avoid the danger of polarization, it being feared that the jarring of the train would disturb the present arrangement of the molecules, unless the position of the glass should be changed, and all lines of disturbance thus broken up.

THE BINARY STAR δ EQUULEI*.—It will be remembered that the period of this, the most rapid of known binaries, was considered by M. O. Struve to be either 6–7 years or 13 years. Subsequently Mr. Burnham, from an examination of the measures made from 1852 (the date of discovery) to 1883·55 ('Observatory,' Vol. vii. p. 13), came to the conclusion that the period must be about 10·8 years. Recently Prof. Glasenapp, having had his attention directed to this interesting object, requested Herr Wrublewsky, one of his pupils, to compute the elements of the orbit. Using the same observations as Mr. Burnham, the resulting orbit gave for time of periastron passage 1892·03, for eccentricity 0·2011, for semi-axis major 0″·406, and for period 11·478 years. These elements do not, however, represent the observations of position-angle satisfactorily, and Prof. Glasenapp hopes that possessors of large refractors will pay some attention to this binary, in order that the orbit may be more accurately determined. Herr Wrublewsky's elements give for the epoch 1887·24, position-angle = 204°·9, and distance = 0″·48.

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* Astron. Nachrichten, No. 2771.

THE ROUSDON OBSERVATORY.—We have received Mr. C. E. Peek's Report on the work of his observatory during 1886. During the year transit observations for time have been taken on all available nights, of which there were 146. Long Period Variables, the great nebula in Andromeda, and Comets 1885 *d* and *e*, 1886 *a*, *b*, *c*, *e*, and *f*, were observed with the 6·4-inch equatoreal. No repairs or alterations of the building have been required, and the machinery for working the dome and transit-shutters is in perfect order.

THE HARVARD COLLEGE OBSERVATORY.—Prof. Pickering has issued his Annual Report as Director of the Harvard College Observatory, which was presented to the Visiting Committee on December 7, 1886. Various series of observations have been carried on during the year with the East Equatoreal. Amongst them may be mentioned the photometric observations of the eclipses of Jupiter's satellites (39 of which have been observed since the end of October 1885), the observations of Comparison Stars for Variables with the wedge photometer, observations of the New Stars in Orion and Andromeda, and observations of Comets. With regard to the meridian circle, Prof. Pickering states that the reduction and publication of work already done with this instrument is at present more desirable than the prosecution of new series of observations. The resignation of Prof. W. A. Rogers deprives the Observatory of a valued assistant, who has devoted many years to the meridian work. An arrangement has, however, been made by which he will still retain the superintendence of this work, and its publication will be completed as soon as possible. With the Meridian Photometer 209 series of measures have been made during the year, the total number of separate photometric comparisons being 59,800. The average deviation of the 100 circumpolar stars employed as standards is 0·12 of a magnitude with this photometer, whilst the value of this quantity was 0·16 with the smaller instrument employed in the Harvard Photometry. Fainter stars are measured with still greater accuracy, the average deviation of stars from the fifth to the ninth magnitude but little exceeding one tenth of a magnitude. A comparison of the 700 stars common to the observations of Wolff, of Pritchard, and the Harvard Photometry showed that the latter differed on the average from Wolff by 0·140 of a magnitude; from Pritchard by 0·145; while Wolff and Pritchard differed from each other by 0·192. A comparison of the 55 stars proposed by Prof. Pritchard as standards showed that the average deviation of his results from the Harvard Photometry was only 0·104 of a magnitude. A comparison of the results obtained at Pulkowa by Lindemann with the Zöllner photometer and at Harvard College with the meridian photometer shows that the average deviation of a measure of the difference in brightness between two stars, as determined with these two instruments, does not exceed 0·1 of a magnitude. Very interesting and important results have also been obtained in stellar photography, but having been recently commented on in our pages ('Observatory,' No. 119, pp. 76, 77) it is unnecessary to refer to them more at length on the present occasion.

REDUCTION OF THE PLACES OF CLOSE POLAR STARS FROM ONE EPOCH TO ANOTHER*.—A paper entitled 'A Catalogue of 130 polar stars for the Epoch 1875·0, resulting from all the available observations made between 1860 and 1885, and reduced to the system of the Catalogue of Publication XIV. of the Astronomische Gesellschaft,' was communicated to the American Academy at the meeting of June 16, 1886, by Prof. W. A. Rogers and Miss Anna Winlock. The first part of the paper has now been published, and contains an investigation of the methods to be followed in bringing up the places of close polar stars for a number of years, taking into account precession only. Prof. Rogers appends a note to the effect that his connection with the work is limited to the methods of discussion adopted, and to an examination of the numerical results obtained. Beyond this all the work in the preparation of this paper has been done by Miss Winlock, and she is entitled to all the credit therefor. By actual computation, taking the instance of Groombridge 1119 (a star whose declination for 1875 is +88° 59′ 38″), it is shown that it is impossible to obtain an exact agreement between the results obtained by Taylor's theorem and those resulting from the rigorous trigonometrical formulæ when the time exceeds forty years. But it is also shown that the time at which the values derived from the development by Taylor's theorem begin to deviate from those derived from the exact formulæ may be extended many years by means of a secondary series, which represents the residuals between the exact coordinates and those obtained with any assumed limit to the terms of the series. The application of this principle to the case of Groombridge 1119 is explained in full, and results given which enable the computer to calculate the co-ordinates corresponding to any date between 1875 and 1955, and also between 1875 and 1755. Miss Winlock's paper is one the preparation of which has necessarily involved a great amount of labour, and astronomers engaged on investigations relating to the positions of close polar stars will find her researches of much use to them. We hope that the publication of the second part of the paper, treating of the proper motions of close polar stars, the final Catalogue and its comparison with the various Catalogues from which it has been derived, &c., will not long be delayed.

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* 'Memoirs of the American Academy,' Vol. xi. part iv. no. v.

SPECTROSCOPIC METHOD OF DETERMINING THE DISTANCE OF A DOUBLE STAR.—Mr. A. A. Rambaut, in a paper recently communicated to the Royal Irish Academy, discusses the conditions under which the spectroscopic method for determining the motions of stars in the line of sight may be used for ascertaining the distance of a binary. The inquiry is not a new one, Prof. Niven ('Monthly Notices,' Vol. xxxiv. p. 339) and Prof. E. C. Pickering (Proc. Amer. Acad. vol. viii. no. 1) having both given formulæ for the annual parallax of a binary, when the elements of the orbit and the relative speed of motion in the line of sight of the two components at a given time are known. Mr. Rambaut, however, adds a table, in which he gives the maximum value of $\pi . V$ for 39 double stars, π being the annual parallax in seconds of arc, and V the velocity of motion in the line of sight in miles per second. All double stars for which k $(=\pi . V)$ is at any time greater than unity, Mr. Rambaut considers to be within measurable distance, since either π or V must be of determinable amount. But if k be smaller than unity, and V be large, then the binary must be at an inconceivable distance, and quite beyond our means for ascertaining its parallax. The table annexed to the paper does not, however, give any hope that the spectroscopic method will be of much general value for determining stellar distances. For only 5 stars is k greater than unity, and only one of these, α Centauri, is really well fitted for such delicate spectroscopic examination. For this star, however, the method might give as accurate a value of the distance as the ordinary mode of parallax; certainly it is worth while attempting it, and we recommend it to the attention of observers in the southern hemisphere possessing powerful telescopes.

ROTATION PERIOD OF THE RED SPOT ON JUPITER*.—From eight observations in the spring of 1886, Prof. Young deduces a rotation period for this object of $9^h\ 55^m\ 40^s{\cdot}7 \pm 0^s{\cdot}2$. Comparing this value with those of Prof. Hough for the four preceding oppositions, it appears that the remarkable retardation of the period still persists. Prof. Young also determined the period of a small white spot in a higher latitude than the red spot (50° S.) and found it considerably shorter than that of the red spot ($9^h\ 55^m\ 11^s{\cdot}14$); it therefore seems that there are spots on both sides of the red spot travelling more quickly than it does. Prof. Young also adds some remarks on the junction of the southern belt with the red spot described by Mr. Denning in the 'Observatory' for May 1886, p. 188.

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* Sidereal Messenger, Dec. 1886, p. 289.

PUBLICATIONS OF THE LIVERPOOL ASTRONOMICAL SOCIETY'S OBSERVATORY.—No. 1 of this series of publications contains two papers by Mr. Espin, the Observer to the Society, viz. (1) Photographic Photometry, and (2) Spectroscopic Observations. The first of these contains the magnitudes of some 500 stars occurring in the DM. zone +40°, as deduced generally from two plates taken on different dates, the method of reduction being the same as that adopted in the author's 'Catalogue of the Magnitudes of 500 Stars.' The DM. magnitudes are also given for comparison. The average discordance of the magnitudes deduced from each of the two plates is about ·15 of a magnitude; whilst the average discordance of the determinations of Espin and Argelander is about ·3 of a magnitude. In attempting to find the effect of colour upon the photographic magnitude, the following table has been found to represent the differences very fairly:—

Red......	+2·5	Yellow-orange..	+1·3	White......	−0·0
Orange-red	+1·9	Yellow........	+0·8	Bluish-white	−0·5
Orange ..	+1·6	Yellowish-white	+0·4	Blue	−1·6

Wratten and Wainwright's plates have been used, the instrument being the Grubb Equatoreal Stellar Camera of 4½ inches aperture.

The spectroscopic observations contained in the second of these papers were made with the Calver equatoreal of 17¼-in. aperture, the spectra being observed by means of five prisms, equalling two direct-vision prisms, placed before an eyepiece magnifying 200 times. The stars observed (about 65 in number) are chiefly red stars and others with remarkable spectra, the general character of the spectrum being in each case indicated.

THE WARNER OBSERVATORY.—Prof. Lewis Swift has published a pamphlet giving a history and account of the work at the Warner Observatory, Rochester, N.Y., 1883–1886. A description of the great 16-inch refractor, the dome, and other accessories is also given. Searching for new nebulæ and for comets is the principal work to which Prof. Swift has devoted himself; and he gives a catalogue of the positions, with descriptions, of upwards of 400 of the former class of objects which have been discovered at the Warner Observatory. The pamphlet also contains the essays on Comets and on the Sky-glows, to which prizes have been adjudged, as well as a list of the recipients of the well-known Warner prizes for cometary discoveries.

PROF. BREDICHIN ON COMETARY TAILS.—Prof. Bredichin has recently examined into the characteristics of the tails of the three principal comets of last year. The first two comets, Comet 1885 *d* (Fabry), and Comet 1885 *e* (Barnard), had tails of the second type, but only rough values for $1-\mu$ could be obtained, since both were difficult to observe. The values Prof. Bredichin deduced were 1·3 and 1·9 for the two comets respectively. But the third comet,

Comet 1886 *f* (Barnard-Hartwig), was much more interesting since it had two tails, which proved to be of the first and third type respectively; and a third tail was seen on one occasion by Mr. Backhouse between the other two, and evidently very nearly of the character and in the position corresponding to a tail of the second type.

COMETS AND MINOR PLANETS.—Prof. Kirkwood, in a short note in the January number of the 'American Journal,' calls attention to two instances in which a comet would seem to have had its origin in the zone of asteroids. Wolf's comet, 1884 III., had an eccentricity smaller than that of twelve of the minor planets, with a mean distance 4·611 and a period of about 3619 days, previous to its last encounter with Jupiter, so that it would seem to have been simply a very distant asteroid. The orbit of Tempel's comet, 1867 II., resembles that of No. 87, Sylvia, in inclination, longitude of node, and period; its eccentricity is greater, however, than that of Sylvia, but does not much exceed that of No. 132, Aethra. In a further note in the 'Sidereal Messenger' for March, Prof. Kirkwood points out that this comet corresponds to the gap in the minor planets at distance 3·277. The distance 3·9683, where a planet would have a period two-thirds that of Jupiter, lies just beyond the outer limit of the cluster as at present known, the mean distance of Hilda being 3·9523. Should a minor planet at mean distance 3·9683 have an eccentricity of 0·3, its aphelion would be further from the Sun than the perihelion of Jupiter, and the orbit might not be stable. The orbit might be entirely changed like that of Lexell's comet, or it might be thrown into a cometary form without the period being much changed. Two comets, Faye's and Denning's, have periods about two-thirds that of Jupiter, and in like manner the periods of the comets of D'Arrest and Biela correspond to the gap at distance 3·51.

VARIATIONS IN THE SUN'S DIAMETER*.—In this paper Herr Auwers gives a very exhaustive discussion of the value of the Sun's horizontal and vertical diameter, found from meridian observations, with special reference to the alleged variations in the mean annual values thereof, following the period of the Sun-spot cycle, the existence of which has been asserted by Secchi and others, as well as other periodic or progressive changes. The series of observations discussed are:—(1) Greenwich Observations 1851–1883, (2) Washington Observations 1866–1882, (3) Oxford (Radcliffe) Observations 1862–1883, and (4) Neuchâtel Observations (transits only) 1862–1883. The personal equations of the several observers are first determined on the supposition that the Sun's diameter may be variable, and that therefore the observations of each observer must be compared with those of the other observers made in the same year only. The mean annual values of both the horizontal and

* 'Sitzungsberichte der königlich preussischen Akademie der Wissenschaften zu Berlin,' No. 50, December 2, 1886.

vertical diameter for the several series of observations, resulting from this discussion, show variations both of a periodic and non-periodic character, the former at first sight appearing to bear some resemblance to the Sun-spot curve; but by comparing them carefully with this curve, and with each other, Herr Auwers comes to the conclusion that there is no valid reason for supposing the Sun's diameter to vary in the manner supposed, and that the apparent changes arise from insufficiently determined personal equations. He accordingly proceeds to determine these afresh, on the supposition that the mean annual diameter is constant, but that the personal equations, at least for some observers, are liable to change. This second discussion leads to much more satisfactory results, and Herr Auwers regards it as the legitimate conclusion to be drawn from his investigations. As an instance of the effect of personality on measures of the Sun's diameter, it may be stated that the mean of the 33 years' observations with the Greenwich Transit-Circle, referred to the mean of Dunkin, Ellis, Criswick, and J. Carpenter as standard, is

Horizontal diameter 32′ 2″·48, from 3114 observations.
Vertical diameter 32 2 ·00, from 3289 observations.

Whilst the same series of observations referred to the "Mean Observer" as standard gives

Horizontal diameter 32′ 2″·01 } from 62 observers.
Vertical diameter 32 2 ·73 }

The mean results (referred in each case to the "Mean Observer") for the other series of observations are:—

Washington,	hor. diam.	32′ 2″·45,	vert. diam.	32′ 2″·57	……	15 observers.
Oxford,	„	32 2 ·87,	„	32 3 ·51	……	7
Neuchâtel,	„	32 3· 27,			……	8

Herr Auwers points out that meridian observations are quite unsuited for determination of any possible ellipticity in the Sun's disk, and that there is no reason to conclude from these results that such ellipticity exists. The several mean values of the Sun's (assumed circular) diameter are—Greenwich 32′ 2″·37, Washington 32′ 2″·51, Oxford 32′ 2″·19, and Neuchâtel 32′ 3″·27; the discordances of which are to be ascribed to instrumental, or uneliminated personal, peculiarities.

NEW MINOR PLANET.—A New Minor Planet, No. 265, was discovered by Herr Palisa on February 27. This is the 58th discovered by this observer, and it will probably prove to be an important one, for, as M. Bigourdan has pointed out*, its motion in R.A. is unusually rapid, about double the average motion of an asteroid. It must therefore be comparatively very near the Earth, and may in consequence be of much value for the determination of the solar parallax.

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* Comptes Rendus, Tome civ. No. 9.

New Red Star.—The Rev. T. E. Espin telegraphs that he has discovered a new red star, magnitude 7·5, three minutes south and 5 seconds following 26 Cygni. There is no star in the DM. at this place. The star shows a very well-marked spectrum of the third type. Place of 26 Cygni, 1887·0; R.A. $19^h\ 58^m\ 9^s$, Dec. $+9°\ 46'·9$.

The Numerical Lunar Theory, upon which Sir G. B. Airy has been engaged for so many years, has just been published. We offer our heartiest congratulations to our veteran leader on the completion of his Herculean task, and rejoice that the health and strength necessary for the carrying on of so large a work have been preserved to him so long.

M. A. Lancaster has brought out a second edition of his very useful 'Liste Générale des Observatoires et des Astronomes.' He has very carefully revised it, and the errors and omissions noticed before seem now to have been corrected. It is a particularly useful little work.

Minor Planet No. 262 has received the name of Valda.

Ephemeris for Comet 1886 *e* (*Finlay*) *. By H. Kloock.

For Berlin Midnight.

1887.		R.A.			Dec.			Log Δ.	Ab. Time.	
		h	m	s	°	′	″		m	s
April	1..	5	12	8·51	+25	17	54·4	0·32421	17	30
	4..	5	19	35·55	25	25	36·5	0·33564	17	58
	7..	5	26	55·16	25	31	51·2	0·34682	18	26
	10..	5	34	7·45	25	36	43·2	0·35773	18	55
	13..	5	41	12·91	25	40	16·4	0·36839	19	23
	16..	5	48	11·78	25	42	34·8	0·37879	19	51
	19..	5	55	4·26	25	43	42·4	0·38893	20	19
	22..	6	1	50·67	25	43	42·5	0·39883	20	47
	25..	6	8	31·05	25	42	38·1	0·40847	21	15
	28..	6	15	5·77	+25	40	32·7	0·41787	21	43

Elements and Ephemeris for Comet 1887 *b* (*Brooks, Jan.* 22) †.

By R. Spitaler.

From normal places for Jan. 24 derived from observations at Washington, Cambridge, U.S., and Albany; for Feb. 11 from observations at Berlin, Kiel, and Strasbourg; and for Feb. 25 at Vienna.

T=1887 March 17·0500, Berlin M.T.

$$\left.\begin{array}{ll} \omega \ \ldots\ldots\ldots\ldots & 159°\ 10'\ 16''·5 \\ \Omega \ \ldots\ldots\ldots\ldots & 279\ \ 50\ \ \ 2\ ·7 \\ i \ \ldots\ldots\ldots\ldots & 104\ \ 18\ \ \ 3\ ·5 \end{array}\right\}\ \text{Mean Eq. 1887·0.}$$

log q .... 0·213036

---

* Astron. Nachr. No. 2777.

† Ibid. No. 2776.

Error of middle place (O−C).

$\Delta\lambda \cos\beta = +0''\cdot4 \qquad \Delta\beta = +0''\cdot9.$

$$x=[9\cdot473245]\,r\sin(v+304^\circ\ 6'\ 43''\cdot3)$$
$$y=[9\cdot999376]\,r\sin(v+\ 44\ \ \ 1\ 16\ \cdot1)$$
$$z=[9\cdot980581]\,r\sin(v+134\ \ 57\ 37\ \cdot2)$$

Ephemeris for Berlin Midnight.

1887.	R.A. h m s	Decl. ° ′	Brightness.	Ab. Time. h m
April 1	4 30 21	+30 43·9	0·61	15 56
5	4 35 58	28 30·2	0·56	16 33
9	4 41 21	26 26·4	0·51	17 10
13	4 46 31	24 31·2	0·47	17 47
17	4 51 31	22 43·6	0·43	18 22
21	4 56 23	21 2·6	0·40	18 57
25	5 1 8	19 27·3	0·37	19 30
29	5 5 47	+17 57·0	0·44	20 3

The brightness on January 24 is taken as unity.

Elements and Ephemeris for Comet 1887 *d* (*Barnard, Feb.* 16)*.

By Drs. J. Palisa and H. Kreutz.

From observations obtained at Paris on Feb. 17, at Strassburg Feb. 23, and at Vienna Feb. 28.

T=1887, Mar. 28·4862, Berlin M.T.

$$\left.\begin{array}{ll} \omega \ \dots\dots\dots\dots & 36^\circ\ 33'\ 24''\cdot8 \\ \Omega \ \dots\dots\dots\dots & 135\ \ 27\ \ 11\ \cdot4 \\ i \dots\dots\dots\dots & 139\ \ 46\ \ 53\ \cdot4 \end{array}\right\}\ \text{Mean Eq. } 1887\cdot0.$$

$\log q$ .... 0·002736

Error of middle place (O−C).

$\Delta\lambda \cos\beta = -7''\cdot5 \qquad \Delta\beta = +9''\cdot7$

$$x=[9\cdot95014]\,r\sin(v+343^\circ\ 29'\cdot1)$$
$$y=[9\cdot83734]\,r\sin(v+105\ \ 55\ \cdot8)$$
$$z=[9\cdot93236]\,r\sin(v+\ 55\ \ 35\ \cdot9)$$

Ephemeris for Berlin Midnight.

1887.	R.A. h m s	Decl. ° ′	Log r.	Log Δ.	Brightness.
Mar. 31 ..	3 5 0	+35 42·2	0·0033	0·1479	0·36
April 4 ..	3 0 40	36 8·0	0·0058	0·1786	0·31
8 ..	2 56 51	36 30·2	0·0102	0·2056	0·27
12 ..	2 53 26	36 49·9	0·0164	0·2292	0·23
16 ..	2 50 21	37 7·8	0·0242	0·2498	0·21
20 ..	2 47 33	37 24·4	0·0334	0·2677	0·18
24 ..	2 44 58	37 40·2	0·0438	0·2832	0·16
28 ..	2 42 34	37 55·6	0·0552	0·2965	0·14

The brightness on March 11 is taken as unity.

* Astr. Nachr. Nos. 2776 and 2777.

ERRATUM IN No. 121.

Page 115, line 15, for $\frac{225}{32}m^2$, read $\frac{225}{32}m^3$.

123.] MAY, 1887. [*Price* 1*s*.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
eting of the Royal Astronomical Society on April 6 177
eting of the Liverpool Astronomical Society 184

ticles:—
elenographical Notes. By THOS. GWYN ELGER, F.R.A.S. 187
eteor Notes. By W. F. DENNING, F.R.A.S. 188
nternational Astronomical Congress 190

rrespondence:—
he Motion of the Red Spot on Jupiter. By A. STANLEY WILLIAMS, F.R.A.S. 193
he alleged change in the Colour of Sirius. By W. T. LYNN, B.A., F.R.A.S. 194
he Variability of ε Aquilæ. By W. T. LYNN, B.A., F.R.A.S. 194
he Occultation of the Hyades. By GEORGE WILLIAMS, F.R.A.S. 195
he Examination of Stellar Photographs. By T. W. BACKHOUSE, F.R.A.S. 196

tes:—
Method for the Determination of the Constant of Aberration.—'Lunar Science.'—The Engelhardt Observatory.—Harvard College Observatory.—Solar Activity in 1886.—Telegraphic Determination of Australian Longitudes.—Braun's *Cosmogony*.—'Contributions to Meteorology.'—The Parallax of Σ 1516.—Declinations of the brighter Stars in the Northern Hemisphere.—The Horizontal Diameter of the Sun.—Minor Planets.—The Total Solar Eclipse of 1886, August 29.—The Orbit of Eucharis.—The Right Ascension of certain Fundamental Stars.—Astronomical Photographs at the Paris Observatory.—Total Solar Eclipse of 1887, August 19.—Dr. L. Thollon.—Mr. Lynn's 'Celestial Motions' 196–208

nents of Comet 1886 *e* (Finlay) 208
emeris for Comet 1887 *c* (Barnard, Jan. 23). By Dr. H. KREUTZ 208

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CONTENTS OF No. 122.

Meeting of the Royal Astronomical Society on March 11 ....
Meeting of the Liverpool Astronomical Society ....

Articles:—

Selenographical Notes. By Thomas Gwyn Elger, F.R.A.S. ....
Meteor Notes. By W. F. Denning, F.R.A.S. ....

Correspondence:—

The Variable Star Lal. 10063. By E. J. White, F.R.A.S. ....
The Dark Ring of Saturn. By Thomas Gwyn Elger, F.R.A.S. ....
Noises accompanying Auroræ. By Henry J. Webber ....
Aratus and Hipparchus. By W. T. Lynn, B.A., F.R.A.S. ....
Saturne—Compagnon de Sirius. By Dr. F. Terby, F.R.A.S. ....
The Colours of the Stars and the Solar Heat. By W. H. S. Monck, M.A., F.R.A.S. ....
Sir W. Herschel. By G. F. Chambers, F.R.A.S. ....
A Southern Comet. By John Tebbutt, F.R.A.S. ....
Photography and the Determination of Stellar Parallax. By A. Cowper Ranyard, M.A., F.R.A.S. ....

Notes:—

The Lick Observatory.—The Binary Star δ Equulei.—The Rousdon Observatory.—The Harvard College Observatory.—Reduction of the Places of Close Polar Stars from one Epoch to another.—Spectroscopic Method of determining the Distance of a Double Star.—Rotation Period of the Red Spot on Jupiter.—Publications of the Liverpool Astronomical Society's Observatory.—The Warner Observatory.—Prof. Bredichin on Cometary Tails.—Comets and Minor Planets.—Variations in the Sun's Diameter.—New Minor Planet.—New Red Star.—The Numerical Lunar Theory.—Editorial Notes 168

Ephemeris for Comet 1886 *e* (Finlay). By H. Kloock ....
Elements and Ephemeris for Comet 1887 *b* (Brooks, Jan. 22). By R. Spitaler
Elements and Ephemeris for Comet 1887 *d* (Barnard, Feb. 16). By Drs. J. Palisa and H. Kreutz ....

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 123. MAY. 1887.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Wednesday, April 6, 1887.

E. Dunkin, Esq., F.R.S., *Vice-President*, in the Chair.

Secretaries: E. B. Knobel and
Lieut.-Col. G. L. Tupman.

The Minutes of the previous Meeting were read and confirmed.

Col. Tupman said that amongst the 95 presents received since the last meeting were 31 books presented by the Royal Society. These books were all valuable works, and one in particular, a copy of the 'De Scientiæ Stellarum,' a rare book and difficult to obtain.

Mr. Knobel. I would like to remark that we are very much indebted to the Royal Society for this copy of the 'De Scientiæ Stellarum' of Albategnius. For three years I have been unsuccessfully searching for a copy. It is altogether a very valuable work to us.

Votes of thanks were passed to the donors.

Mr. Chambers in presenting a "Catalogue of Red Stars" said that it was the outcome of many hundred observations extending over a period of seventeen years, 1870 to 1886 inclusive. The telescope employed at first was a 4-in. reflector, but the observations made since 1884 had been with a 6-in. refractor. The catalogue made no pretence at being exhaustive; it must be regarded more as a working list designed to facilitate the study of red stars, of not less than the 8½ magnitude. It might be that the eyes of the present race of observers were not so sensitive to red light, but he certainly had often considered that many of his predecessors in the observation of red stars had greatly exaggerated the colours. Taking the so-called red stars all round, his opinion was that a more generally accurate generic term for them would be orange stars. Very few of them approached to red, and less than a dozen could be termed carmine or ruby. These remarks were requisite by way of caution in order to guard inexperienced observers from being disappointed when they came to examine stars described by Sir William Herschel, Sir John Herschel, Schmidt, and others as red or very red. These observers no doubt saw stars of a redder tinge than they had since been found to exhibit. In the case of the Herschels, this might have been due to the character of their metallic mirrors or to peculiarity of eyesight, or to both causes combined. The results of his own original work included 589 stars examined by himself out of a total of 711, being virtually all those visible in England. He remarked on the fact that many of the stars which were certainly variable were red, and that many of the red stars, since they were first noted as such, had been found to be variable. The coincidence between the redness of colour and the variability of the light of several hundred stars could not be accidental. What it meant he did not presume to suggest. The question had often been discussed as to how far flat-surface diagrams of colour were of any use as standards of comparison of the colour of stars. For his own part he was disposed to question their usefulness. He thought a transparent disc of coloured glass arranged in gradations of colour and mounted on a frame sufficiently portable to be held in the hand by the observer, while his eye was looking through the telescope, might be used for the comparison of star-colours. The light wherewith to illuminate the discs might perhaps be obtained by means of electricity. The catalogue included red stars recently brought under the notice of the Society by Mr. Espin, so far as he had been able to examine them. He had also included a few which he had not been able to examine, in order to make the catalogue as fairly complete as possible.

Capt. Noble. When Mr. Chambers was occupied in preparing the catalogue of red stars for his most valuable work, 'Descriptive Astronomy,' he spent a night in my observatory and we went over a list of red stars he had brought. As far as my memory serves me, we made out between us two thirds of the stars to be orange and the remaining one third we could not make out to be anything but white. With regard to the determination of the colours of stars by means of discs, I have tried Admiral Smyth's chromatic scale; but I always found that it looked so extremely different in the daylight in my library from what it did when I was groping about at night with a bull's-eye lantern, and with my eye to the telescope, that it was impossible to use it as a means of comparison or to regard it as an accurate means of describing the colours of the stars.

Dr. Gill. I came across a curious case of difference in the estimation of colour in examining the object-glasses of two well-known opticians, Mr. Grubb and Dr. Schroeder. Mr. Grubb in object-glasses obtains a good coincidence of the rays much more towards the red end of the spectrum than in the case of Dr. Schroeder, who leaves a considerable quantity of outstanding red in order to keep the rays towards the blue end of the spectrum. I have no doubt that both opticians were guided simply by the different sensibility of the eye to colour—Mr. Grubb's eyes being more sensitive to red rays and Dr. Schroeder's to blue rays.

A vote of thanks to Mr. Chambers for his paper was passed.

Mr. Knobel then read a paper by *Mr. Howard Grubb* on "The choice of Instruments for Stellar Photography."

The author in submitting these notes to the Society did not claim any peculiar originality for them; they were suggestions showing the many points which must be thoroughly discussed before a satisfactory conclusion could be come to as to the best instrumental equipment for this new class of work. First as to the instrument:—theoretically considered, the reflector appeared the superior for the reason that, if spherical aberration be properly corrected, there is no dispersion, all rays being brought to the same focus, whereas in the refractor it was not so. Again, the field of view of the reflector was theoretically flatter; but at the same time it had been pointed out by Lieut.-Gen. Tennant that a considerable amount of "coma" was found in the lateral pencils of the reflector, which coma distorted the star discs. The value of General Tennant's paper would be largely increased if extended to show the *comparative* results for lateral pencils in the refractor. So far as he (Mr. Grubb) was able to judge, there really was not much to choose between the photographs taken with the two kinds of instruments up to the present time. The author then pointed out that more experiments were required to find the effects of increase of actual aperture, and also for increase of angular aperture. As regards the *field of view*, he thought that present results tended to show that 2° × 2° was the maximum attainable with really good definition.

Remarks on the choice of "silver-on-glass" and "metallic" mirrors, and on the size and mounting of the instrument, then followed.

In speaking of the effects of refraction Mr. Grubb said:—"Taking a star near the equator and on the meridian, the difference in declination for short periods is small, or about $0''\cdot5$ in half an hour, while in R.A. the change would amount to the same quantity in only two minutes. The curious part being that this change in R.A. is nearly constant for a considerable distance from the meridian, though of course the error is of opposite sign on different sides of the meridian. The practical deduction to be drawn from this is a very important one, viz.:—that, instead of exposing the plates across the meridian, the whole exposure should take place either E. or W. of the meridian, and then if the clock be given a slight + rate in exposing E. and a slight – rate when exposing W., the troublesome element of refraction will not enter into the question." Further on Mr. Grubb remarked that the adoption of curved plates might add considerably to the field photographed. In conclusion he said:—"It appears to me that the most useful work the Paris Congress could do would be to formulate a series of experiments which would clear up all debatable points. Arrangements might also be made to enable the work to be carried on immediately after these experiments were completed, the general features of the instrumental equipment to be contingent on the result of the experiments."

The Chairman. As a supplement to these very important papers, I will now call upon Dr. Gill, who will address the meeting upon the same subject.

Dr. Gill. It will probably be in the memory of the Society that in 1882, with the aid of Mr. Allis, the photographer at Mowbray near Cape Town, we obtained photographs of the great comet of that year, that these photographs contained pictures of stars nearly down to the 9th magnitude after 2½ hours exposure, and these photographs gave rise to the idea that by means of such lenses—compound lenses of the type of the rapid rectilinear lenses of Dallmeyer—observations by photographs of stars to the 9th and 9½ magnitudes on the system of Argelander might be rapidly secured. I laid before the Royal Society a proposal to that effect on the occasion of my visit to England in 1884, and by the generosity of the Government-Grant Fund of the Royal Society, the services of Mr. Ray Woods were engaged and the work has been in progress. That work had gone on for some time, when some photographs were sent to me by Messrs. Henry of Paris. The quality of work which they produced was infinitely superior to anything we obtained at the Cape. The quality of definition was due in the first place to the superior lenses which they employed; and, secondly, to the much more rapid plates which they used. But there is a distinctive difference between the leading idea of the photographs obtained at Paris and those which have been obtained at the Cape. Messrs. Henry, who had undertaken to complete the charts of Chacornac, found, when they reached the region of the "Milky Way," the ordinary methods of observation impracticable. The idea then arose of securing the desired end by successive photographs of small adjoining areas. The work I had undertaken at the Cape was of a totally different character and intention. My intention was to complete for the southern hemisphere the work begun and carried out in the north by Argelander: and it was necessary in carrying out such a work to devise some system which would render that work possible within a limited number of years, and which would admit of after measurement and discussion. The plates of Messrs. Henry only cover an area which at the outside may be represented by two degrees square. The Cape plates give pictures of an area of over 5 degrees square, which are sufficiently sharp for accurate measurement at least to $\frac{1}{10}$th of a minute, and we believe almost to a single second. These pictures are sufficient for that purpose. Therefore by such a process we get comparatively quickly over the stile. I am told by Capt. Abney that the plates I employed, those of the Paget Price Plate Co., 13 years ago, which were the quickest I could obtain, can now be replaced by plates of his invention which work eight times as rapidly, and therefore we shall be able to work, if not eight times as quickly, at least four or five times as rapidly as at present. I wish to show how far this work at the Cape is a work that, notwithstanding the superior results of Messrs. Henry in many respects, should be still carried to completion. It is quite certain that within a very few years, probably two years now, in view of the increased sensitiveness of the plates we can procure, we shall finish the photographic work, and I have been extremely fortunate in finding a colaborateur in Prof. Kapteyn. He has entered into the matter with the greatest enthusiasm, and has undertaken to devote the whole of his time and also that of two or three assistants for seven years to the work. He will measure and reduce photographs showing stars to the number of 500,000 in the southern hemisphere, that is carrying throughout the southern hemisphere the work of Argelander. Now I think we shall advance the progress of astronomy very little if we merely produce a series of pictures containing stars to a particular magnitude, if we do not provide the means of determining for the epoch at which those pictures were taken the precise co-ordinates of all those stars. How alone can we provide for the determination of the co-ordinates of all those stars? That can only be done by obtaining about the same epoch a sufficient number of standard stars upon each plate, so that by determining the linear co-ordinates of these stars we can determine the co-ordinates relatively to them for the whole number of stars in each of those plates. The first step in that process is to have a complete list of all stars in the heavens down to a certain magnitude, with their positions approximately determined, so that we can deliberately and almost immediately make the necessary selection of the comparison stars for each of these plates, and see that those stars are determined at once or as soon as possible by the existing meridian instruments available. Unless it is done systematically and thoroughly, one great part of the work of this Paris Conference will be thrown away. If you have the means of determining exactly the scale-value on the plates, you have the means of discussing one particularly interesting problem. Take the motion of the solar system through space: we know that towards the point of space to which the Sun is advancing the stars will be opening out, and that from that point they will be closing. If you have an accurate determination of the scale-value in each of these plates, then all those plates will be changing their scale-value in one direction in that part of the sky to which the Sun is advancing, and *vice versâ*. That will be one of the points which will be thoroughly neglected, unless it is very seriously considered at the Conference. Unless we fix our ideas primarily upon the determination of the scale-value of these plates, and the means of determining the position and shrinking of the film and the distortion of the glass, we shall not be doing our duty in this matter. I think the work we are doing at the Cape will contribute very much to that end, and I hope that that view will be shared by the Congress; and I hope that I shall be able to carry the work to completion.

Mr. Turner. May I ask if Dr. Gill considers the relative proper motions as shown on one of these small plates would be of any value towards determining the proper motion of the solar system?

Dr. Gill. I think so.

Mr. Common. This subject is so vast that it is utterly impossible to discuss all the questions to which Mr. Grubb has alluded in his interesting and valuable paper. Now that the Conference is coming so very near, we are all getting intensely interested in the subject that we have had before us more or less for the last two or three years. It seems to me there are some very important questions as to the lines upon which the work should be carried on. We have to determine the scale upon which the work has to be done. That would be determined by the length of time which has to be devoted to this work. There is the plan Dr. Gill is now following at the Cape, viz.: taking very large areas of the sky by means of the double combination; this seems to be condemned on all sides, as inadequate for forming a photographic chart of the heavens.

Dr. Gill. Will you allow me to state that I by no means put forward the Cape scheme as better than the scheme of the Paris Conference, but merely as a little preliminary to clear the way? I hope that point will be understood by all of you.

Mr. Common. You are doing it?

Dr. Gill. Yes.

Mr. Common. That is the important thing. If it is done now and has to be superseded by the Paris work, it becomes of very little, if any, value; in fact it is a positive waste of time.

Dr. Gill. Excuse me, the point is this—it is clearing the way for making a greater work of value, otherwise you will not have a sufficient number of known stars on a small plate to determine the places of the remaining stars.

Mr. Common. It may be an advantage to have a great number of known stars on a small plate, and, if it is an advantage, it should be done in the northern hemisphere too.

Dr. Gill. You have Argelander's map already for the northern hemisphere.

Mr. Common. I do not say it is an utter waste of time: I will withdraw that; but it seems to me the time should have been used in photographing the heavens on a larger scale; but there is not the slightest doubt that the heavens can be photographed on such a scale as this—36° at a time. It shows a great deal of determination and pluck on the part of Dr. Gill to begin single-handed; but I think it is rather a pity it was not begun on a better scale; but I rather take this as an example of one way of doing the work. There are three different ways open to us. The chart may be taken on this scale, which must necessarily be small—the very construction of the instrument, the double combination of achromatic lenses, keeping the size small. I do not say but what, if you spend money, you cannot have lenses of 12 or 14 inches aperture; but it is very problematical. I think the lenses Prof. Pickering used at Harvard College, of 8 inches aperture, are about the limit to which you can go in that combination, unless you prolong the exposure and limit the stars photographed to the 10th or 11th mag. Is it of any use taking surveys of the heavens where the limiting magnitude is less than any of our maps? Argelander's limit is between 9 and 10.

Dr. Gill. We have not an Argelander in the south; that is just what we want.

Mr. Common. There is next a single combination, the refracting telescope, where the field is very much restricted, but the range of magnitude of the stars is very much increased; and there is the reflector. This paper of Mr. Grubb's is an important one, as dealing more particularly with the suitability of the two kinds of telescopes which must necessarily be used in any chart that is made. It is too long a matter to discuss at length. I would mention the conclusion I have come to in the consideration of the thing. However valuable the reflector may be for the purpose of light-grasping power, for its cheapness, and from the fact that it does not disperse the light of the star, I think the proper instrument for taking the first photographic chart of the heavens at the present time will be a refractor, not only for the permanency of the light-grasping power, but for the permanency of adjustment. I have submitted a paper (which is not now before the Society) to the Committee of the Congress, and I have suggested the use of the lenses in duplicate or triplicate, so that pictures may be taken of the smaller parts of the sky at the same time. Possibly the Conference may decide on some course to follow; and if they discuss the question in all its details, and experiments are taken in the way many of our Fellows think advisable, there cannot but be a great gain to astronomy.

A vote of thanks was then passed to Mr. Grubb.

Mr. Turner then read a paper "On the Variations of Level and Azimuth of the Transit-Circle of the Royal Observatory, Greenwich." He said that the means of the monthly errors in level and azimuth of the transit-circle at the Royal Observatory had been collected, and he thought it might be of interest to discuss the harmonics by which the annual changes were expressible. It was pointed out some time ago by Mr. Ellis that both the level and azimuth followed the temperature very closely; and he had for comparison added the analysis of the mean temperature. There was a variation of nearly four seconds amplitude in azimuth and nearly two seconds in level: the azimuth followed the temperature by about a month and a half, while the level appeared to anticipate it by that amount. This latter effect he considered to be due to a difference of conductivity in the piers of the instrument.

Dr. Gill. I may say that Mr. Finlay has made a most careful investigation of the azimuth of the Cape transit-circle from the foundation of the instrument to the present time; and those results are now prepared for, and will pass through, the press before I leave this country. The conclusion at which Mr. Finlay arrives is, in the case of the level at all events, that the maximum and the minimum are reached four months after the maximum and minimum of temperature. There is also an additional investigation of some interest which Mr. Turner does not seem to have carried out, namely the expression for secular changes.

Mr. Turner. Those are shown in the paper, but I thought them hardly of sufficient interest to comment on; they are shown by the fignres.

Dr. Gill. They are very difficult to explain, but are extremely interesting to follow.

The Astronomer Royal. I may, perhaps, add a word of caution with regard to secular changes of the Greenwich transit-circle. There have been various changes made in the azimuth and level, and of course it is necessary to take this into account; and the consequence is the whole period of observation is broken up into periods of a few years generally, so that there is no very long period, if I remember right, to show the distinct secular changes.

Mr. Turner. The longest period is from 1851 to 1869.

The Chairman (in proposing a vote of thanks to Mr. Turner) said that those matters might perhaps seem technical to an outsider, but to those in charge of an observatory they were intensely interesting, and, indeed, particularly so to himself, as an old observer.

The following papers were also announced:—

Prof. C. Pritchard. "Remarks on some of the present aspects of Celestial Photography."

J. E. Gore. "On the Orbit of OΣ 400."

C. L. Prince. "Lunar Occultations on March 29, 1887."

A. Marth. "On the formulæ for computing the apparent positions of a Satellite, and for correcting the assumed Elements of its Orbit."

Royal Observatory, Greenwich. "Observations of Comet *b* 1887 (Brooks)."

The following gentlemen were duly elected Fellows of the Society:—

Rev. John Bone, Lieut. W. F. Caborne, R.N.R., Lieut. Campbell W. M. Hepworth, R.N.R., and William Frederick Smith.

The Meeting adjourned at $10^{h}\ 0^{m}$ P.M.

Liverpool Astronomical Society.

The seventh general meeting of the session was held on Tuesday, April 12. Mr. James Gill, Vice-President, in the chair. Ten Members were elected and 11 candidates proposed, and Lord Crawford and Dr. Dunér were elected Honorary Associates of the Society. A large number of communications in support of Mr. Elger's resolution, "that the next annual meeting be held in London," were read, and upon the question being put to the vote it was carried unanimously.

In a paper on the Proper Motion of ζ Ursæ Majoris and its naked-eye companion (Mizar and Alcor, the *eques stellula* of old), Mr. Herbert Sadler said it had long been known that these two components were moving together through space with the same velocity and in the same direction. It was therefore a matter of interest to ascertain whether the small star, which forms the triangle with them, partook of their common movement. Of this star, Smyth relates that, in 1723, a German astronomer thought he had discovered a new wandering star near ζ, and, not remarking that it was a strange location for a planet, immediately dubbed it *Sidus Ludovicianum*, in honour of his sovereign, Louis V. of Hesse Darmstadt. This was probably the 8th magnitude star to the southward of Alcor, and its location would perhaps not have appeared so "strange" if it could have been known that the position of *Euphrosyne* on January 17, 1867, would be R.A. $\text{VIII}^{h}\ 42^{m}\ 20^{s}\ +61^{\circ}\ 31'{\cdot}7$, and consequently not far from 5 Ursæ Majoris. From a presumed identity of proper motion, a physical connection had been suspected, and Smyth even assigned a period of 190,000 of our years, though this was probably an error. The brightness of Sidus Ludovicianum had been variously estimated from the 6th to 8½ mag., so that it might almost certainly be classed as variable.

The Rev. S. J. Johnson remarked upon the interesting occultation of the Hyades which took place on March 29. Although the Moon had on this occasion set before reaching Aldebaran, there was some compensation from the fact of that wide pair θ^1 and θ^2 Tauri being occulted; not only because they were such a noble pair in the telescope, but also remarkable from the suspicion—or, according to W. Struve, more than suspicion—of a physical connection, notwithstanding their wide distance apart. θ^1 disappeared at $9^{h}\ 18^{m}\ 37^{s}$ and θ^2 at $9^{h}\ 27^{m}\ 50^{s}$, both disappearances being instantaneous, and easily visible in a small single-lens opera-glass.

In the conclusion of his essay on the Temperature of Stars, Mr. W. H. S. Monck contended that if their heat and size varied, as they had reason to believe, it was clear that they must not look exclusively amongst the brightest stars for their nearest neighbours. Few of the bright stars, for example, were as near as 61 Cygni, and yet this was near the limit of naked-eye vision. The companion of Sirius, which could only be seen with a very powerful telescope, was as near to us as its primary. The very faint 40^2 Eridani had also a sensible parallax, and there was little doubt that we might hereafter discover a tenth, or even a twelfth, magnitude star with a greater parallax than α Centauri. Until recently, chance only could lead astronomers to hit upon such a star, but photographs might now be taken of regions which might hereafter show displacement; and, though this would not indicate parallax, its evidence of large proper motion would form one of our best guides to the nearness of stars.

On the supposition that astronomical causes underlie and determine physical agencies, Mr. M. Fergus reviewed the different theories which account for glacial epochs. The mean annual amount of solar heat might remain fixed, but, with an eccentricity of 0·0747, and winter in aphelion, the Earth would be 8 million miles further from the Sun, and the temperature of the British Isles 6° Fahr. below zero. Further there was the increased length of aphelion winter, which, taken at its maximum, varied from 33 to 36 days longer than the summer. With the southern winter at aphelion, the south of Patagonia and the Falkland Islands (lat. from 50° to 55° S.) were covered with snow and ice to the edge of the sea. Geology revealed repeated interglacial periods, though it did not explain them; but astronomy and meteorology together afforded strong evidence that a glacial climate would prevail on that hemisphere which had its winter at aphelion during an epoch of extreme eccentricity of the Earth's orbit.

Mr. George Higgs did not think the present low eccentricity of the Earth's orbit would account for these differences of climate in aphelion winter, but attributed the relatively high temperature of northern latitudes to the warm air-currents, and to the action of the Gulf-stream.

Mr. James Gill thought it was not safe to rely too much on the Gulf-stream as a modifier of climate, since Dr. Carpenter had proved, during the expedition of the 'Challenger,' that it was dissipated before getting halfway across the Atlantic. The present mild winters were rather due to the returning warm ocean-currents from tropical regions, which flowed in a direction from S.W. to N.E., as a consequence of the Earth's rotation. Both the initial direction of these currents and the trend of the land favoured their projection on to the British Isles.

In a continuation of his articles on Telescopic work, Mr. W. F. Denning dealt with town definition, and enjoined observers residing in populous districts not to despair of doing really useful work. The vapours hanging over a large city were by no means so objectionable as was commonly supposed, unless they were moving rapidly across the field of view. In a comparatively tranquil state of the air, definition was excellent, and he had frequently found planetary markings very sharp and steady through the smoke and fog of Bristol; the interposing vapours, indeed, moderated the brightness of the image with excellent effect. Vapour from neighbouring chimneys was, of course, ruinous, as a bright star was transformed into a seething cometary mass, and the planets underwent contortions of a most astonishing character.

The work of the meteoric section, under the direction of Mr. Denning, included the simultaneous observation of a meteor, which was first seen on the 19th January by Mr. Monck at Dublin, when 56 miles high, over a point S. by W. from Holyhead. Mr. Backhouse had noticed it directly afterwards when it was 49 miles high, and from thence it descended to an elevation of 28 miles between Carnarvon and Dublin. The whole of the visible path was 33 miles, and its velocity slightly more than 22 miles per second, the radiant being near λ Draconis. No shower had ever been observed from this point in January. The only position which fell anywhere near it was that given in the 'Companion to the

ervatory' for 1885, page 3 (or February [illegible]
radiant was determined by Mr. Denning from a number of
ting-stars recorded by Denza and other Italian observers in
–1872.

apers were received from Mr. W. H. S. Monck on col-
urs, and from Mr. George Higgs on prominent lines in the
.

he meeting adjourned at 9.30 P.M.

Selenographical Notes.

E CAPUANUS RILL AND THE RAMSDEN RILL-SYSTEM.—In
midt's representation of the Capuanus rill it is shown as
ending with a few short breaks from the north-east side of
siodus to a long spur jutting out from the northern wall of
puanus. Mädler, who failed to trace it for some distance east
the hilly region between Cichus and Hesiodus, draws a short
ction of it north of Capuanus, but not reaching so far east as the
ur, while Neison shows it as an unbroken line from its western
igin to this latter object. There are, in fact, no gaps or solutions
continuity in its course between these extremes, except where
e mountains which border the Mare Nubium on the south-east
rike across its direction. It is open to doubt whether the rill
s ever been rigidly followed through this barrier, though I have
two or three occasions seen it in a very attenuated form on the
stern flank of these mountains. At 9h on April 3, when the
orning terminator passed about midway between Ramsden and
itello, it was traced in a continuous line from Hesiodus to the
pur from Capuanus, except where the heights just mentioned
tervene. At this time the remarkable group of rills lying west
f Ramsden was favourably seen, as well as the three somewhat
oarser clefts which, coming from the north, abut on the border of
his formation. In Schmidt's special chart of this region, attached
o his 'Rillen auf dem Monde,' he shows a short rill, 5, branching
ut from two others on the west of Ramsden, and running towards
he west. At times of best definition I saw that the Capuanus
ill extended east of the spur and joined this object, passing on its
way a little north of a small craterlet which Schmidt represents in
the form of a circular mound. At the place where the rill traverses
the spur there is also a distinct craterlet not shown in the maps.
The extension of the Capuanus rill to the Ramsden group is noteworthy from a physical point of view, the more so as the former
is, as regards its course, to a great extent an exceptional object of
its class. The direction of by far the majority of lunar clefts
seems to be intimately related to the trend of neighbouring
mountain-ranges, and to the configuration of the borders of
Maria, or other smaller natural features; but here we h

instance of one of these mysterious furrows striking boldly across a wide alluvial tract, and traversing a lofty mountain-system nearly at right angles to its axis, without any apparent reference to the character or structure of the region through which it passes. The western half of the rill, or that portion which lies on the Mare Nubium, is a fine object, with high powers, about the time when the morning terminator intersects Capuanus—its many variations in width being then prominently displayed.

In connection with the Ramsden rill-system, Dr. Klein, of Cologne, made, a few years ago, the suggestive observation that that section of the north wall of this ring-plain, included between the rills which abut on it (numbered 9 and 10 in Schmidt's special map in his 'Rillen'), is greatly disturbed and shifted from its normal position towards the exterior. The phenomenon was recorded with a high power, when the morning terminator lay a little east of Ramsden. Though I have never been fortunate enough to observe this very remarkable physical feature, I can nevertheless confirm Dr. Klein's observation to the extent of seeing that Neison's assertion ('Moon,' p. 378), that Ramsden has entirely intercepted the rill-system of which it is the centre, needs modification as regards the two rills just mentioned, as they have been traced as delicate dark lines through the wall.

Kempston, Beds, 1887, April 21. THOS. GWYN ELGER.

Meteor Notes.

ON March 23, 24, 25, and 27, in watches amounting in the sum to 5¼ hours, 33 meteors were seen at Bristol. A radiant-point of rather slow meteors was found at 161° +58° near β Ursæ Majoris, chiefly on March 25, and another, of swift meteors, at 229° +32°, on March 27. Further showers were observed from 175° +20° and 190° +20°. The latter is probably associated with a stream that has been noticed on several occasions in April. The Italian observations of 1872 give a radiant at 190° +20°, Mar. 31–April 12; Heis has a position at 190° +23°, April 4–23; Shiaparelli and Zezioli, 193° +20°, April 11, 1869; and Corder 190° +20°, April.

On March 28 I observed 35 meteors during a watch of about 5 hours, in the interval from 10^h to $15\frac{1}{2}^h$. The chief shower was one of slow meteors from 263° +62°, about 5° S.E. of ζ Draconis. This stream does not appear to have been recognized before in March, though several radiants cluster hereabout in April.

Between March 24–28 I registered several conspicuous meteors from a point at 316° +76° near χ Cephei. Two fine ones were also seen from this place in 1877 on March 16 and 18. Showers have been previously observed at the same position in the spring months. I deduced a radiant at 300° +80° for Feb. 1–Mar. 12

from the Italian observations, 1872, and another at 300° +79°, May 3–15. Heis also gives radiants at 320° +81°, April 14–28, and 315° +81°, May 5–June 15. Greg and Herschel found a centre at 305° +80°, April 27–June 30. These determinations serve to show that several distinct meteor-groups emanate from the same region round about χ Cephei.

The brightest meteor seen here in March was on the 28th, at $12^h\ 53^m$. It was = ♃, and fell rather swiftly from 333° +50° to 345½° +40°. Meteors exceeding 1st-mag. stars were also noticed on March 24, $10^h\ 3^m$, and March 27, $8^h\ 50^m$ and $11^h\ 29^m$. The one observed on March 27 at $8^h\ 50^m$ moved very slowly, and left a bright train just S. of the stars ζ, η, and θ Draconis. The apparent path was from 267° +66° to 243° +57°, and the radiant was evidently situated in an unusual position in the western sky. It is fortunate this meteor was also observed by Mr. Backhouse at Sunderland, where it appeared low in the south, to the W. of Felis, traversing a short path of about 6°. Mr. Backhouse described it as 1st mag., of yellow colour, and it left a faint sparkling train. The direction of its flight was accurately recorded both at Sunderland and Bristol, and the radiant-point derived from the combined tracks is at 11° +34° (a few degrees W. of β Andromedæ). This position had an altitude of 10° in N.W. at the time of the observation. When first seen, the meteor was about 55 miles high over a point of the Earth's surface E. of Walsall, and after pursuing a course of 26 miles, it became extinct near Leamington, at an elevation of 50½ miles. It emanated from a stream hitherto quite unknown, for no radiants have ever been found near β Andromedæ in the spring months of the year.

The Lyrids of 1887.—The weather this year proved exceptionally favourable at the period of recurrence of this display. At Bristol observations were commenced on April 17, when, in a watch of 2¼ hours between 10^h and 13^h, 11 meteors were counted; but there were no Lyrids. On April 18, in 4½ hours between 10^h and 15^h, 27 meteors were seen, including 4 Lyrids, from a radiant at about 266° +33°. On April 19, in 4½ hours, between 10^h and $14\frac{3}{4}^h$, 30 meteors were registered, and of these 5 were Lyrids, with radiant at 269° +31°. On April 20, in 3 hours between $9\frac{3}{4}^h$ and 13^h, 18 meteors were seen; and 7 were Lyrids from 271° +32°. Summarizing the three nights (18th, 19th, and 20th), 16 Lyrids appeared out of a total of 75 shooting-stars seen in 12 hours' watching. The maximum occurred on the 20th, when the number of Lyrids rather exceeded 2 per hour for one shower. The display has therefore been a decidedly poor one. The few Lyrids that were recorded were very swift, brilliant, flashing meteors, leaving thin streaks. What the shower has lacked in regard to numbers has, however, been in a measure compensated for by the very conspicuous character of the individual meteors. The radiant determined on successive nights has shown a progressive displacement amongst the stars, though not to the extent witnessed in 1885.

On April 19, 1887, 13h 13m, a very fine Lyrid (= ♀) fell rapidly from 269° +11° to 269° +1°. Near the visible end-point the meteor flashed out with great brilliancy, and left a broken streak for several seconds lying amongst the small groups of stars in Taurus Poniatowski.

It is noteworthy that my descriptions of these meteors as seen in different years are curiously discordant. In 1878 I found them slow-moving, and in 1884, when the shower was unusually rich, they were faint and uninteresting, with motions by no means swift. This year their great swiftness and brilliancy formed the most striking features.

During my late observations I recognized the following minor streams as being well pronounced:—

h	Radiant.	Notes and Comparisons.
1....	165° − 6°	Meteors very slow; seen on April 17–18.
2....	218 +33	Bright, slow meteors. Near ρ, δ Boötis.
3....	213 +53	Small, swift, and short. S. & Z., 212° +55°, April 14.
4....	231 +17	Very swift. D., 231° +17°, April 18–20, 1885.
5....	272 +21	Very swift. The *Cerberids* of Greg.

The shower at 231° +17° W. of β Serpentis is unusually definite and exact. The position at 272° +21° also represents another prominent stream of the Lyrid meteoric epoch. This shower was observed by Prof. Herschel on April 13–14, 1864, at 273° +25°, and by Mr. Greg on April 20, 1872, at 267° +25°. On April 19, 1877, I saw it at 267° +21°. W. F. DENNING.

Bristol, 1887, April 21.

International Astronomical Congress.

THE International Congress which had been invited by Admiral Mouchez to assemble in Paris on April 16, was attended by the following Astronomers and Savants:—MM. Auwers, Baillaud, Bakhuysen, Bertrand, Beuf, Bouquet de la Grye, Brunner, Christie, Cloué, Common, Cornu, Cruls, Donner, Dunér, Eder, Elkin, Faye, Fizeau, Folie, Gautier, Gill, Gylden, Hasselberg, Paul Henry, Prosper Henry, Janssen, Kapteyn, Knobel, Krueger, Laussedat, Liard, Loewy, Lohse, Mouchez, Oom, Oudemans, Pechüle, Perrier, Perry, Peters, Pujazon, Rayet, Roberts, Russell, Schoenfeld, Steinheil, Struve, Tacchini, Tennant, Thiele, Tisserand, Trépied, Weiss, Winterhalter, Wolf, &c.

The conference, which was held at the Observatory, was opened by M. Flourens, the Minister for Foreign Affairs, who in the name of the French Government offered the members a cordial welcome. The business of the conference was conducted by a Bureau of

which the Honorary President was Admiral Mouchez; Acting President, M. Struve; Vice-Presidents, MM. Auwers, Christie, and Faye; Secretaries, MM. Bakhuysen and Tisserand; Assistant Secretaries, MM. Dunér and Trépied.

The following general resolutions were adopted by the Congress:—

1. Les progrès réallisés dans la Photographie Astronomique exigent impérieusement que les astronomes de notre époque entreprennent en commun la description du ciel par le moyen des procédés photographiques.

2. Ce travail sera fait dans les stations à choisir et avec les instruments qui devront être identiques dans leur parties essentielles.

3. Les buts principaux seront:—

- α. De dresser une carte photographique générale du ciel pour l'époque actuelle, et d'obtenir des données qui permettront de fixer les positions et les grandeurs de toutes les étoiles, jusqu'à un ordre déterminé avec la plus grande précision possible (les grandeurs étant entendues dans un sens photographique à definir).
- β. De pouvoir aux meilleurs moyens d'utiliser tant à l'époque actuelle que dans l'avenir, les données fournies par les procédés photographiques.

The resolutions with regard to Instruments, Magnitude of Stars, Photographic processes, Measurements, &c. may be classified thus:—

Instruments.

1. Les instruments employés seront exclusivement des refracteurs.

2. L'ouverture de l'objectif doit être d'environ $0^{m}\cdot33$ et la distance focale de $3^{m}\cdot43$, de sorte qu'une minute d'arc soit représentée approximativement par $0^{m}\cdot001$.

3. L'aplanétisme et l'achromatisme des objectifs employés seront calculés d'après les radiations voisines de la raie G de Fraunhofer. Cette resolution sera entendue dans ce sens, que la distance focale minimum sera celle d'une raie voisine de G, en vue d'atteindre le maximum de sensibilité des plaques photographiques.

4. Les objectifs seront construits de manière que le champ utilisable pour les mesures soit de 1° au moins à partir du centre.

5. Les tubes des instruments photographiques seront construits avec le métal le plus favorable pour obtenir un plan focal invariable, et porteront une graduation pour la détermination et la réglage de la position des plaques.

Magnitude of Stars.

Les étoiles seront photographiées jusqu'à la 14^{e} grandeur inclusivement, cette grandeur étant indiquée provisoirement par l'échelle

actuellement en usage en France et sous la réserve que sa valeur photométrique sera définitivement fixée ultérieurement.

Photographic Plates.

1. Toutes les plaques seront préparées suivant une formule unique à déterminer ultérieurement.

2. Il sera institué un contrôle permanent de ces plaques au point de vue de leur sensibilité relative pour les différents radiations.

Orientation of plates and determination of co-ordinates, &c.

1. Outre l'épreuve qui doit donner les étoiles jusqu'à la 14ᵉ grandeur, il sera fait une série d'épreuves à plus courtes durées d'exposition pour assurer une plus grande précision dans la mesure micrométrique des étoiles de repères et rendre possible la construction d'un Catalogue.

2. Les clichés supplémentaires destines à la construction du Catalogue contiendront toutes les étoiles jusqu'à la 11ᵉ grandeur inclusivement.

3. Chaque plaque photographique, destinée à la formation du Catalogue sera accompagnée de toutes les données nécessaires pour obtenir son orientation et la valeur de son échelle: autant que possible ces données se trouveront inscrites sur la plaque elle-même. Chaque plaque de cette espèce portera une copie bien centrée d'un système de repères dérivé d'un réseau et destiné à assurer la détermination des erreurs du champ, et à éliminer les erreurs qui pourront être produites par une déformation ultérieure de la couche sensible.

All other questions of detail were referred to the permanent Executive Committee.

It was resolved that the Permanent Committee should consist of all Directors of Observatories taking part in the work, and others not necessarily joining in it, but whose assistance and counsel would be of especial value; the number was limited to 11. The following were elected on this section of the Committee:—MM. Christie, Dunér, Gill, Prosper Henry, Janssen, Loewy, Pickering, Struve, Tacchini, Vogel, and Weiss.

It is with much satisfaction we are able to announce that this important conference, which terminated its labours on Monday, April 25, has already borne fruit, inasmuch as the Governments of France, Brazil, and the Argentine Republic have at once decided to take part in the work, and the observatories of Paris, Bordeaux, Toulouse, Algiers, Rio, and La Plata have received the necessary instructions.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Motion of the Red Spot on Jupiter.

GENTLEMEN,—

Observations made here recently indicate that the long-continued retardation in the motion of the red spot has now ceased, and a slight acceleration taken place. The following are the times at which the centre of the spot was observed to be on the central meridian of the planet's disk, with the intervals of time by which it preceded Mr. Marth's zero meridian, system II.:—

	G.M.T.		Precedes Marth's zero mer. by
	h	m	m
1886, Dec. 20......	16	49	11·0
1887, Jan. 1......	16	50	6·0
Feb. 26......	13	6	4·8
Mar. 20......	11	14	3·9
27......	11	56	6·9
29......	15	25	15·8
Apr. 3......	12	38·2*	9·7
8......	11	42	12·8
10......	13	11	21·8
17......	14	3*	14·7
21......	11	32·7*	14·1

The rotation-period given by these observations is $2^{s}\cdot1$ less than that assumed by Mr. Marth in his ephemeris, system II., or $9^{h}\ 55^{m}\ 38^{s}\cdot5$. In the spring of 1886 Prof. Young found it to be $9^{h}\ 55^{m}\ 40^{s}\cdot7$ ('Observatory' for April last, p. 171), and in 1884–85 Prof. Hough gives it as $9^{h}\ 55^{m}\ 40^{s}\cdot4$. The spot must now be expected on the central meridian at about 15^{m} before the times given by Mr. Marth in the 'Monthly Notices,' and about 40^{m} before those given on p. 36 of the "Companion" to the 'Observatory.'

Seen under moderately favourable conditions, the red spot is an easy object in my 6½-in. Calver reflector, and with a clearly discernible reddish tint. Owing to the southern declination of Jupiter, however, good views are not often obtainable, and the estimated intervals of time by which it precedes the first meridian, as will be noticed, frequently differ considerably *inter se*. Those observations which were made under favourable circumstances, and are therefore more to be depended on, are marked with an asterisk.

The surface of the spot is of nearly, but not quite, the same intensity. Lately a narrow dark streak has been seen extending from the dark, very prominent, elbow of the south equatoreal dark belt, just following the red spot, to the following tip of this latter object, and continued from thence a short distance along the south following edge of the spot. A similar feature has been visible in former years.

Yours faithfully,

A. STANLEY WILLIAMS.

West Brighton, 1887, April 23.

The alleged change in the Colour of Sirius.

Gentlemen,—

In his letter printed in this month's number of 'The Observatory,' Mr. Monck suggests that the names of the stars of the first magnitude now in use in our hemisphere were selected with reference to their colours, those commencing with the earliest letters in the alphabet being decidedly red, and the others less so as we proceed. It is difficult, however, to see how the selection can have been made in this way, since, as Mr. Monck himself truly remarks, the names are of different origin and did not originate at the same time. I may be also allowed to remind him that the syllable "Al" is as much the Arabic definite article in "Aldebaran" as it is in "Altair."

The first person, I believe to suggest a change of colour in Sirius and its redness in ancient times was Mr. Barker, of Lyndon in Rutland, in a paper printed in the 'Philosophical Transactions' for 1760, vol. li. part 2; but he is obliged to admit that Hyginus "seems to call Sirius white," though he urges that the word "candor," applied by Hyginus to Sirius, may be taken to mean "brightness, without regard to colour." That word, however, undoubtedly usually means "whiteness;" and as I have shown that it is probably a mistake to suppose that the ancients attributed a red colour to Sirius, there is no need to take the "flammæ candor" of Hyginus in any other than its natural sense.

Yours faithfully,

Blackheath, 1887, April 13. W. T. Lynn.

The Variability of ε Aquilæ.

Gentlemen,—

Attention was, I believe, first called to the possible variability of this star by Sir William Herschel in the volume of the 'Philosophical Transactions' for 1796, on the ground that it appeared much fainter to him than it did to Flamsteed. No one seems to have noticed it before Tycho, who registered it as of the third magnitude, whilst Flamsteed and Hevelins found it of the fourth. In the 'Almagest' one star only is mentioned in the tail of Aquila, on the margin of the Milky Way, nor is any other alluded to in the catalogues either of Al-Sûfi or of Ulugh Beigh. It is almost incredible that this should have been the case if ε and ζ Aquilæ had been of nearly equal magnitude as they were in the time of Tycho, or even been of their present respective magnitudes, about the third and fourth. Flamsteed in the column for reference to Ptolemy in the 'British Catalogue' affixes the figure 9 to both ε and ζ Aquilæ (the single star mentioned in the 'Almagest' as situated in the tail of Aquila being the ninth in the list of stars in that constellation), presumably as considering that it was impossible to say which of those stars was the one intended. But the fact that ε has again diminished in brightness since his time may be admitted to prove that ζ was the one observed by Hipparchus, Ptolemy, Al-Sûfi, and Ulugh Beigh, and that ε is a variable of long period.

It would appear indeed to have undergone some other mutations of brightness in recent years. Sir William Herschel, in the place above referred to, states that he found it on the 3rd of September, 1784, of only between the fifth and sixth magnitudes. He remarks, indeed, that it was then observed in strong twilight, but says that it was "not much larger than either 11, 18, or 19," the magnitudes of which are respectively 6, 5½, and 6. Mr. Gore estimated it in August 1875 of about 4½ magnitude, and "very little, if anything, brighter than 111 Herculis," which is of about 5½ magnitude. Mr. Franks, too, found it on June 20, 1879, "nearly two magnitudes less than ζ Aquilæ and equal to 111 Herculis; Sept. 12, 1879, a little brighter than 110 and 111 Herculis; certainly brighter than on June 20." On the other hand, Prof. Pickering, in his 'Meridian Photometry' (from observations made between 1880 and 1882), registers it of magnitude 4·1, and Prof. Pritchard, in the 'Uranometria Oxoniensis,' assigns 3·86 as the magnitude in 1882. It would appear therefore that the variations in brightness of this star are worthy of careful study, and that perhaps their period may be not very long.

Yours faithfully,
W. T. LYNN.

Blackheath, 1887, Mar. 4.

The Occultation of the Hyades.

GENTLEMEN,—

An unusually fine sky enabled the three occultations which took place last night to be well observed here. During the early part of the same night, time was obtained by transits of seven stars, high and low.

	h. m. s.	
θ^1 Tauri, disappearance	9 13 41	G.M.T.
θ^2 Tauri, „	9 22 7	„
B.A.C. 1391 „	9 29 26	„

The last differing much from the time given in the 'Nautical Almanack.'

The reappearance was lost to view, the moon having disappeared behind one of the mountains with which this place is surrounded. Telescope 4·25 inches aperture, 62·5 inches focal length, equatoreally mounted; Lat. 52° 47′ 45″ N., Long. 3° 53′ 30″ W., by ordnance survey.

Faithfully yours,
GEORGE WILLIAMS.

Dolmelynllyn, Dolgelley,
1887, Mar. 30.

those from Dehra Dûn) supply a record of the period which is complete, except for Nov. 17 and Nov. 30, and show that for the 38 days beginning Oct. 31 and ending Dec. 7 there were only 7 days on which even a single spot was shown, and even for these 7 days the mean daily area was only 7-millionths of the Sun's hemisphere. Since the close of this remarkable period of quiescence, there has been a little more activity manifest, but the spots are still, on the whole, few, small, and insignificant; and there have been four periods—viz.: 1887 Jan. 9–18, Feb. 7–16, Mar. 3–17, and Mar. 28–Apr. 17—in which the Sun has been almost or entirely free, even from the smallest spots. Prof. Tacchini has been so much struck with the unusual character of this period of quiescence as to speak of it as possibly the true minimum of the present period*. The comparatively high latitude of the mean spotted area (viz. 10°·7 for the year 1886), as well as the unprecedentedly short interval which has elapsed since the maximum, only 2·8 years (the mean interval from maximum to minimum being 7 years), tend to render this very unlikely; the more so, that so long a period of quiescence, though undoubtedly very unusual except at the actual minimum of the eleven-year cycle, has not been without analogies in former instances. Thus, M. Riccò†, searching the Palermo records, finds that in 1875 also there was a very pronounced secondary minimum nearly comparable in character to that of last November, and he points out that though this last depression has followed the maximum much more closely than that of 1875 did the maximum of 1870, yet that the interval from the epoch of the previous eleven-year minimum has been about the same in each case, viz. nearly eight years. Other facts, too, indicate that we have now reached a similar point in the descent from maximum to minimum to that attained in 1875; for if the past year be taken on the whole, the numbers of the spots, their mean daily area, and their latitude correspond fairly closely to the same particulars for 1875: indeed, the numbers are rather higher for 1886, and seem to show that it marks a slightly earlier stage of the period. The following table gives the elements referred to for 1874, 1875, 1885, and 1886:—

Year.	Mean Daily Area.	Wolf's Relative Numbers.	Mean Latitude.
1874.	601	43·1	10°·9
1875.	272	18·9	10·6
1885.	811	56·3	11·8
1886.	370	25·7	10·7

The mean area is expressed in millionths of the Sun's visible hemisphere. These figures would lead us to expect the next principal minimum to fall about the end of 1889 or beginning of 1890, at an interval of about eleven years from the last. The exceptional which they gave rise. The immediate consequence, however, of their formation is an approach to the Sun within a distance at which its attraction is balanced by the outward gaseous pressure and the centrifugal force. The incipient planet, endowed with the greater angular velocity of the stratum to which it originally belonged, revolves now at a rate slightly superior to that of the new medium in which it finds itself. Hence the possibility of its sweeping up and annexing fresh matter as it proceeds along the coils of its narrowing orbit, until a point is reached where the planet or even Sun has drawn in all the matter which stood in its way, and gravity alone exactly balances centrifugal force. The planet then revolves in an orbit sensibly the same as at present.

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* Comptes Rendus, Tome civ. No. 4.

† Ibid. No. 2.

If we now reflect that the portions of the nebula nearest the Sun are the most dense and the slowest in moving, it is easy to see that the inner side of the planetary mass encounters greater resistance than the opposite, and therefore in the course of time is produced a rotation in the same sense as the revolution.

Further, it will be the exterior shells of the nebulous planet which are most affected by this difference of resistance, and accordingly they rotate faster than the interior portions, to which they have only communicated a part of their motion. Besides, as each new shell is added, it meets with a greater inequality of pressure on both sides than its predecessor, and thus greater speed is generated in it. The planet is now in every way assimilated to the parent nebula, and the evolution of satellites is an exact counterpart to that of their primaries.

In the majority of cases, then, the planets are not produced by rings; still the Saturnian world shows that rings are possible, and Fr. Braun assumes that a ring was formed on the outskirts of the system, giving rise to Neptune with its probable retrograde rotation and the retrograde revolution of its satellite.

Nothing requires that the planets should originate in the solar equator. The direction of general rotation, however, being the direction of least resistance to their motion, there would be a tendency in the orbits to place themselves in that equator, and thus the planets would be ultimately brought to revolve nearly, though not quite, in the same plane.

By giving different rotatory rates to the strata containing the various condensing bodies, we do away with the difficulty that the primaries rotate on the whole much faster than would be required if we suppose that they shed their tributaries when extending to the limit of their orbits. The remains of this unequal rotation of the different shells is still to be seen in the increase of speed as we approach the equatorial zones of the Sun and of Jupiter.

Fr. Braun derives from his theory ingenious explanations of the rapid motion of Phobos, of the swifter rotation of the larger planets, of the increase in their density and the decrease in their mass as we approach the Sun. Mars is an exception; but are reasons for thinking it of later formation, so that when it came into existence, the space allotted to it for its growth was already greatly exhausted, owing chiefly to the powerful attraction of Jupiter.

Many other facts are brought to bear on the proposed theory, and the outline of a theory of the Sun is also sketched. But we must refer to the work itself, or to the review 'Natur und Offenbarung' (from which it has been reprinted), for greater details, as well as for the interesting numerical calculations founded on the laws of mechanics and thermodynamics.

'CONTRIBUTIONS TO METEOROLOGY' (Revised edition, Chapter II. By Professor LOOMIS).—This is the second part of the reprint of these well-known essays. The subject dealt with is Areas of High Pressure, their form, magnitude, direction, and velocity of movement, and the relation of areas of high pressure to areas of low pressure. It seems unnecessary to do more than announce the appearance of this succeeding portion of Professor Loomis's work, since it is difficult to give in a few words any proper account of the information therein conveyed. Besides, all who are interested in the questions treated of will undoubtedly endeavour to consult the work for themselves. The characteristic difference between areas of high and low pressure may, however, be given in the author's words:—"Near the centre of the former [low] area, the winds blew with hurricane violence, as is indicated by the number of the feathers attached to the arrows [on accompanying plates]; near the centre of the latter [high] area, the atmosphere was well-nigh calm. In the former area the winds circulated about the low centre in a direction *contrary* to the motion of the hands of a watch, and at the same time showed a decided tendency *inward* toward the centre of low pressure. In the latter area the winds circulated about the high centre in the *same* direction as that of the hands of a watch, and at the same time showed a decided tendency *outward* from the centre of high pressure." The paper is illustrated by numerous charts, and terminates with a discussion of the theory of barometric fluctuations, and of a formula for the calculation of the barometric gradient.

THE PARALLAX OF Σ 1516 *.—Dr. L. de Ball, of the Observatory of the University of Liège, has recently made a series of measures of relative position-angles and distances of the components of this optical double star for the purpose of determining the parallax of the brighter component (which has a sensible proper motion) referred to the fainter. From 67 measures of position-angle he finds $\pi = +0''\cdot091$ with mean error $\pm 0''\cdot013$, and from 64 measures of distance $\pi = +0''\cdot112$ with mean error $\pm 0''\cdot010$. Combining these results he gets finally $\pi = +0''\cdot104$ with mean error $\pm 0''\cdot008$.

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* Mémoires de l'Académie royale des Sciences, des lettres et des beaux-arts de Belgique, Tome xlix., 1887.

The position of this object for 1885 is R.A. 11h 8m, Dec. +74° 6′, whilst the magnitudes of the components are 7·0 and 7·5 respectively.

DECLINATIONS OF THE BRIGHTER STARS IN THE NORTHERN HEMISPHERE *.—Prof. Respighi has published a catalogue of the mean declinations of 1004 naked-eye stars, reduced to the epoch 1880·0, situated between 0° and 20° and between 64° and 90° of north declination. The places are deduced from observations made with the meridian circle of the Campidoglio Observatory during the years 1879, 1880, and 1881. This catalogue is a continuation of the work embodied in a previous catalogue, published in a preceding volume of the 'Atti,' which gives the places of stars of declination +20° to +64°. The Campidoglio positions depend essentially on those of Auwers' Fundamental Catalogue and appear to be of considerable accuracy.

THE HORIZONTAL DIAMETER OF THE SUN †.—In this paper Prof. di Legge discusses the meridian transits of the Sun's diameter observed at Campidoglio during the years 1874–1883 inclusive. The mean horizontal semidiameter at mean distance, deduced from 5796 transits by four observers on 2213 days, is 961″·188. A speciality of these observations is that since May 1876 the Sun's transit has been observed by projection, thus enabling two or more persons to observe simultaneously, thereby affording exceptionally favourable opportunities for the determination of personal equation. Changes in the habits of the observers will probably account for an apparent progressive diminution in the value of the Sun's horizontal semidiameter, to which Prof. di Legge draws attention.

MINOR PLANETS.—Minor Planets No. 263 and 265 have received the names of Dresda and Anna respectively. Dr. Luther discovered a minor planet on April 11, which, from its magnitude and rate of motion, is probably the missing Hesperia, No. 69. The object observed was about 15m in advance in R.A. of the place given in the ephemeris for Hesperia in the 'Berliner Jahrbuch,' and about 1° 10′ north.

THE TOTAL SOLAR ECLIPSE OF 1886, AUGUST 29.—Dr. Schuster gave a preliminary account of his observations of this eclipse at the meeting of the Royal Society held on March 17. His equipment consisted of three cameras mounted on a single equatoreal stand. One of the three cameras was intended for direct photographs of the corona itself, while the two others were attached to spectroscopes. Three of the photographs obtained of the corona compared well as to definition with those secured during the

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* Atti della R. Accademia dei Lincei, ser. 4a, vol. i. pp. 145–201.

† *Ibid.* pp. 232–281.

Egyptian eclipse, 1882, the exposures ranging from 5 to 20 seconds. One photograph was taken with each of the spectroscopes. The plate taken with the first spectroscope gives good results: a number of lines belonging to the prominences and to the corona are very distinct, and can be measured with fair accuracy. The difficulty of measurement lies in the multitude of lines; between forty and fifty distinct corona lines between F and H have already been measured, and a number still remain unmeasured. A comparison between the photographs of 1882 and 1886 shows that, although the lines seem to be in the same position, their relative intensity has greatly altered. The strongest coronal line during the late eclipse had a wave-length of about 4232; it is slightly but distinctly less refrangible than the strong calcium line at 4226. The second spectroscope (which was arranged with its slit radial to the image of the Sun as formed by the condensing-lens, the first spectroscope having its slit placed tangentially) gave a photograph which, though faint, may probably give good results.

THE ORBIT OF EUCHARIS *.—This minor planet (No. 181) in part of its orbit approaches close to Jupiter, and this circumstance renders a discussion of its motion interesting, as the perturbation due to the proximity of Jupiter will supply an accurate means of determining the mass of the latter. As a preliminary step towards the attainment of this object, Dr. L. de Ball, in the paper before us, has discussed the observations of Eucharis made during the years 1878 (the year of its discovery), 1879, 1880, 1881, 1883, 1885, and 1886, in a very thorough manner, for the purpose of determining the orbit, taking into account perturbations due to Jupiter and Saturn. The places of the comparison stars used in reducing the observations of the planet have been carefully reduced to a uniform system—that of Auwers' Fundamental Catalogue—and no effort spared to render the orbit here presented a satisfactory one.

THE RIGHT ASCENSION OF CERTAIN FUNDAMENTAL STARS †.—Mr. S. C. Chandler, referring to Dr. Auwers' paper in Astron. Nachr. No. 2713 ('Observatory,' Vol. ix. p. 202), points out that Dr. Auwers there gives a list of stars whose places in the 'Fundamental Catalogue' are not quite satisfactory, the adopted places showing a large correction for the position "Greenwich 1861," thereby indicating that the adopted proper motions are probably erroneous. Mr. Chandler has secured 'Almucantar' observations of about half the stars in this list, and the result of his discussion of these "has been to confirm the probable existence of such a defect as the one in question in most of the cases examined." We understand, however, that Dr. Auwers is about to issue a second edition of the 'Fundamental Catalogue,' in which special attention will be

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* Mémoires de l'Académie Royale de Belgique, Tome xlix. (1887).

† The Astronomical Journal, No. 155.

given to the revision of the adopted proper motions wherever it may appear necessary; and under these circumstances it is hardly worth while discussing the proper motions of individual stars in the 'Fundamental Catalogue' until they have been revised by the masterhand of Dr. Auwers himself.

ASTRONOMICAL PHOTOGRAPHY AT THE PARIS OBSERVATORY.—Admiral Mouchez, the director of the Paris Observatory, has recently published a little volume on the above subject, which cannot fail to be of the highest interest to astronomers, especially at the present time, with the special purpose of showing what has been already accomplished in astronomical photography and how fully the results attained so far justify the proposed arrangement for a complete photographic survey of the heavens.

The first section gives a brief sketch of the history of the development of astronomical photography; and refers to the work of De La Rue on the Sun and Moon, to the employment of photography in eclipses and in transits of Venus, to the ingenious uses made of the sensitive plate in stellar photometry and spectroscopy by Prof. Pickering, and to the successful photographs of the great comet of 1882 by Dr. Gill, which seemed unmistakable heralds of such a project as is now under discussion at the Paris Conference.

The second section deals with the labours of the Bros. Henry, and relates how the difficulty they experienced in the work of carrying on the great Ecliptic chart of Chacornac, when they came upon the crowded portions of the heavens in the Milky Way, compelled them to ascertain if photography could furnish them with a means of overcoming it. How successful they were we all know; and the beauty of their first attempts with a small objective, and the importance of the field of research they seemed to open, so struck Admiral Mouchez, that he at once accepted their proposition to construct a large and specially designed apparatus. It is with this latter instrument (described in the 'Observatory,' Vol. viii. p. 219) that MM. Henry have obtained those negatives which have so justly excited the admiration of the astronomical world.

Admiral Mouchez next gives a table of the average exposures necessary for the various magnitudes, which vary from $\frac{1}{200}$ of a second for a first magnitude star to an hour and twenty minutes for one of the sixteenth magnitude; he then describes the method of triple exposure employed by MM. Henry for the purpose of preventing defects being mistaken for stars, and the appearance of the stellar images on the plates when examined under the microscope. These do not appear as more or less uniform stains, but as collections of more or less numerous dots; "a very faint star is a reducible nebula," and other stars are "irreducible nebulæ surrounded by a reducible part." Enlargement of the image at the telescope itself has given excellent results for the Moon, the principal planets, and the brighter stars, since the size of these dots or grains does not undergo a proportional amplification; but for the fainter stars the prolongation of exposure which would be necessary renders the method inadmissible. Then follows a résumé of the actual results obtained at the Observatory, together with specimens. The latter include the clusters in Gemini and Hercules, the lunar regions near Eratosthenes and Archimedes, and a series of photographs of both Jupiter and Saturn. It is unnecessary to describe the latter, as they are sufficiently well known, the beautiful definition of the belts and red spot of Jupiter, and of the polar cap, belts, and rings of Saturn having been made the subject of much commendation; the Cassinian division, it may be mentioned, is distinctly seen, and the difference in brilliancy of the different portions of the rings is strikingly shown. The lunar photographs are less well known, but are full of the sharpest detail, and open out quite a new future for selenography. They are on a scale of about half an inch to a minute of arc. Something has also been done in the observation of double stars; results for 21 of these, as derived from measures of the photographic plates made with a specially constructed micrometer, are here given, and the micrometer itself is described.

The third section deals with the different applications and the future of celestial photography. The list here supplied is a long and important one. There is no single department of astronomy which may not hope for the most valuable services from this new servant of the science; some will, in the future, be wholly dependent upon it. The star-guaging of Sir William Herschel will not be carried on; the examination of the great celestial chart, which, it may be hoped, the next ten or twelve years will give us, will entirely supersede so rough a method. The determination of stellar parallax, of proper motions, of differences of the declinations of stars, the discovery of new variables, the observation of double and multiple stars, stellar photometry, stellar spectroscopy, lunar cartography, the observation of planets and their satellites—will all no doubt, sooner or later, receive the greatest assistance from photography. Admiral Mouchez anticipates that one consequence of the increased application of photography to astronomy will be the development of an entirely new class of astronomers, who, without observatory or instruments, will devote themselves to the study and comparison of the charts of different epochs.

The fourth section is on the Chart of the Heavens, and urges the importance of the immediate co-operation of a number of observatories in that great undertaking, all working on the same plan, on the same scale, and with similar instruments—with some suggestions as to the aperture to be employed, the scale adopted, and the area to be covered by each plate. Each negative ought to have a number of copies taken from it, sufficient at least to supply one to each of the great observatories.

An Appendix follows with notes on the following subjects:—I. List of the principal star catalogues. II. Mr. Roberts's star photographs. III. The refused scheme for creating a branch of the Paris Observatory in a better locality. IV. On the vitrificaion of negatives: M. Salvy, it appears, has been completely successful in thus giving a permanent form to the photographs without injuring them in any way. V. A criticism of some views of Mr. Holden expressed in his recent pamphlet "Photography the servant of Astronomy." VI. On the precision of the measurements made by Prof. Pritchard on stellar photographs. VII. The horizontal photoheliograph. VIII. Provisional programme of questions to be settled at the Photographic Conference.

TOTAL SOLAR ECLIPSE OF 1887, AUGUST 19.—Although no English Government Expedition will be sent out to observe this eclipse, it appears probable that the accessibility of so many places on the line of shadow will induce many English astronomers to proceed to Russia in order to view it. The railway from St. Petersburg to Moscow passes across the shadow-track, Tver being a little to the north of the central line. Moscow itself will be just a little too far south for totality to be seen there, but both the lines from Moscow to Vologda, and that to Kineshma, pass through the shadow. Kineshma itself lies almost precisely on the central line, and Prof. Bredichin, the director of the Moscow Observatory, who has his private observatory some two kilometres from Kineshma, has invited two English astronomers to his house. We understand that Dr. Copeland and the Rev. S. J. Perry have accepted the invitation. Prof. C. A. Young will also be stationed there.

Mr. Common, and Mr. Turner, Chief Assistant at the Royal Observatory, Greenwich, together with Profs. Tacchini and Riccò, will occupy some station in the Government of Vladimir, probably not very far from Kineshma; whilst Capt. Tupman has organized a party which will push further east in order to get a higher Sun and longer totality, and will probably go as far as Perm. A French station will be established at [illegible], on the St. Petersburgh and Moscow railway, and two German parties will be located in the Government of Tver, whilst we hear that an Italian expedition is to penetrate into Siberia as far as Krasnoiarsk. The Russian astronomers will certainly not be behindhand in observing what might fairly be called their own eclipse, since the shadow-track lies so largely within Russian territory, so that there seems good reason to expect that the eclipse of next August will be one of the best observed during the present century.

DR. L. THOLLON.—We greatly regret to announce the death of M. L. Thollon, one of the most able and distinguished spectroscopists that our science possessed. His work with the great spectroscope he had himself devised was of the highest order; and the superb, but unfortunately still unfinished, map of the solar spectrum, to which he devoted the last years of his life, will remain a monument of his patience, energy, and skill. He was well known and highly esteemed by many English astronomers, and his premature death will be widely regretted.

We have received the fifth edition of Mr. Lynn's 'Celestial Motions.' The work has again been thoroughly revised, and the information brought up to the end of last year, as instances of which we may mention the inclusion of the minor planet No. 264, and the references to the return of Winnecke's comet last autumn, and to the probable identity of Finlay's comet with De Vico's. A chapter has also been added on "The Refraction, Propagation, and Aberration of Light."

Elements of Comet 1886 *e* (*Finlay*).

From the following corrected orbit for this object by Prof. A. Krueger*, it appears that it is not, as was at one time suspected, identical with De Vico's comet for 1844. Although its period is so short, only 2433 days, or 6·67 years, it has probably never been observed before. It will return to perihelion in 1893.

T=1886 Nov. 22·42429±0·00206, Berlin M.T.

π	7° 34′ 14″·6±11″·2	Mean Eq. 1886·0.
☊	52 29 58 ·8±29 ·2	
i	3 1 39 ·2± 1 ·7	
ϕ	45 54 22 ·7±50 ·8	
μ	532″·6894±0·395	
U	2432·937 Days.	

Ephemeris for Comet 1887 *c* (*Barnard, Jan.* 23).

By Dr. H. Kreutz.

For Berlin Midnight.

1887.	R.A. h m s	Decl. ° ′	Log *r*.	Log Δ.
May 1....	1 30 47	+66 3·8	0·4057	0·4827
3....	1 39 38	66 13·7		
5....	1 48 22	66 22·5	0·4125	0·4910
7....	1 56 58	66 30·2		
9....	2 5 28	66 36·7	0·4191	0·4991
11....	2 13 50	66 42·4		
13....	2 22 3	66 47·2	0·4257	0·5068
15....	2 30 7	66 51·2		
17....	2 38 3	66 54·5	0·4322	0·5143
19....	2 45 49	66 57·0		
21....	2 53 27	66 58·9	0·4386	0·5215
23....	3 0 56	67 0·3		
25....	3 8 16	67 1·2	0·4449	0·5284
27....	3 15 26	67 1·5		
29....	3 22 27	+67 1·5	0·4512	0·5350

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* Astron. Nachr. No. 2781.

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

Page
Meeting of the Royal Astronomical Society on May 13 209
Meeting of the Liverpool Astronomical Society 216

Articles:—
Selenographical Notes. By T. G. Elger, F.R.A.S. 216
Meteor Notes. By W. F. Denning, F.R.A.S. 217

Correspondence:—
Motion of Jupiter's Red Spot. By W. F. Denning, F.R.A.S. 219
Comets and Asteroids. By W. H. S. Monck, M.A., F.R.A.S. 220
Examination of Stellar Photographs. By E. B. Knobel, F.R.A.S. 221
L'Anneau de Saturne. By Dr. F. Terby 221
La Tache Rouge de Jupiter. By Dr. F. Terby 221
The Great Comet of 1825. By W. T. Lynn, B.A., F.R.A.S. 222
First Discovery of the Great Nebula in Orion. By W. T. Lynn, B.A., F.R.A.S. 222
The Variable Star Lalande [illegible]. By J. G. Porter 223
Proposed Nomenclature for Star-colours. By T. W. Backhouse, F.R.A.S. 224

Notes:—
The Photographic Study of Stellar Spectra.—The Melbourne Observatory.—Prizes for Cometary Discovery.—History of Astronomy during the Nineteenth Century.—The Fraunhofer Anniversary.—Micrometer Measures of Jupiter and Saturn.—Astronomical Photography.—Two New Minor Planets 226-230

Elements and Ephemeris of Comet 1887 e (Barnard, May 12). By Dr. H. Oppenheim 230

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CONTENTS OF No. 123.

Meeting of the Royal Astronomical Society on April 6 ....
Meeting of the Liverpool Astronomical Society ....

Articles:—

Selenographical Notes. By Thos. Gwyn Elger, F.R.A.S. ....
Meteor Notes. By W. F. Denning, F.R.A.S. ....
International Astronomical Congress ....

Correspondence:—

The Motion of the Red Spot on Jupiter. By A. Stanley Williams, F.R.A.S.
The alleged change in the Colour of Sirius. By W. T. Lynn, B.A., F.R.A.S.
The Variability of ϵ Aquilæ. By W. T. Lynn, B.A., F.R.A.S. ....
The Occultation of the Hyades. By George Williams, F.R.A.S. ....
The Examination of Stellar Photographs. By T. W. Backhouse, F.R.A.S.

Notes:—

A Method for the Determination of the Constant of Aberration.—'Lunar Science.'—The Engelhardt Observatory.—Harvard College Observatory.—Solar Activity in 1886.—Telegraphic Determination of Australian Longitudes.—Braun's Cosmogony.—'Contributions to Meteorology.'—The Parallax of Σ 1516.—Declinations of the brighter Stars in the Northern Hemisphere.—The Horizontal Diameter of the Sun.—Minor Planets.—The Total Solar Eclipse of 1886, August 29.—The Orbit of Eucharis.—The Right Ascension of certain Fundamental Stars.—Astronomical Photographs at the Paris Observatory.—Total Solar Eclipse of 1887, August 19.—Dr. L. Thollon.—Mr. Lynn's 'Celestial Motions' ....

Elements of Comet 1886 e (Finlay) ....
Ephemeris for Comet 1887 c (Barnard, Jan. 23). By Dr. H. Kreutz ....

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THE OBSERVATORY,

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No. 124. JUNE. 1887.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, May 13, 1887.

J. W. L. GLAISHER, F.R.S., *President*, in the Chair.

Secretaries: E. B. KNOBEL and
Lieut.-Col. G. L. TUPMAN.

THE Minutes of the April Meeting were read and confirmed.

Col. Tupman. Since the last meeting 75 presents have been received. Amongst these are some wonderful photographs of star-spectra from Harvard College Observatory, which show the greatest advance in this branch of astronomy which has yet been made.

Col. Tupman then read portions of the Harvard College Report.

Votes of thanks were accorded to the donors.

Col. Burton Brown. Would it be possible to publish, in the 'Athenæum' or some other paper, a notice of the subjects of the papers to be read at our meetings? It is often done at other Societies, and would be a great convenience, more especially to country members.

The President. I will take care that the question shall be mentioned at the next Council Meeting.

Capt. Noble. We get so many of the papers coming in on the very morning of the day on which the Council meet, that it is impossible to give notice of them.

Col. Brown. Is there any reason why they should be sent at such a late time?

The President. Papers are received up to noon on the day of the meeting; and I think it is desirable that they should be received as late as possible, especially so in the case of observations of Astronomical Phenomena.

Col. Brown. In certain cases you cannot help it, but there are cases in which you can announce them before hand.

Mr. Knobel. It is by no means certain that any paper would be considered by the Council as suitable for publication, and therefore for reading before the Society. Consequently, if a list were published of the papers sent in, there could be no security that those papers would be read before the Society until the Council had decided and ordered that they should be so read and printed.

The President. I have to announce to the Fellows of the Society that the Council have decided to offer to Her Majesty, who is the Patron of this Society, a loyal address of congratulation on the completion of the 50th year of her reign.

It will be remembered that at the recently held Astronomical Conference in Paris, this Society was invited to send three delegates, and Mr. Common, Mr. Knobel, and Major Tennant were deputed to represent us at that congress. They have brought forward and submitted to the Council a Report of what took place at that congress, and I will ask Mr. Knobel to read that Report to the Meeting.

Mr. Knobel, reading the report, said:—The Congress assembled on the April 16th, in response to an invitation of the Académie des Sciences, and was attended by 55 delegates and representatives of different countries. The eight English representatives were Messrs. Christie, Common, Gill (from the Cape), Knobel, Perry, Roberts, Russell (from Australia), and Tennant. The conference was opened by M. Flourens (Foreign Minister), who expressed a cordial welcome to the members on behalf of the French Republic, and assured them of the cooperation of the Government in the work they might undertake. The following general resolutions, which had been printed in the programme, were first taken into consideration, and adopted unanimously:—1. That the progress made in astronomical photography demands that astronomers of the present day should unite in undertaking a description of the heavens by photographic means. 2. That this work should be carried out at selected stations, and that the instruments used should be identical in their essential parts. 3. That the principal objects are (*a*) to prepare a general photographic chart of the heavens, and to obtain data which shall enable us to determine, with the greatest possible accuracy, the positions and magnitudes of the stars; (*b*) to be able to utilize in the best way, both in the present and in the future, the data obtained by photographic means. A Committee was appointed to consider the best form of instrument to be used, and the least magnitude of stars which it was desirable to photograph. At a meeting on the 18th, it was unanimously resolved that the refractor was the best form of instrument, the dimensions being those of the telescope at the Paris Observatory. The Committee above referred to recommended that the instruments employed should be exclusively refractors; that stars should be photographed to the fourteenth magnitude inclusive; and that the aperture of the object-glass should be 33 centimetres. Directors of Observatories will be free to have their object-glasses made by any optician they desire to employ, provided they comply with the general conditions determined by the congress. Other resolutions were also passed with reference to object-glasses, and to the conditions under which the photographs of the heavens are to be made.

Mr. Common. The Report just read gives such a full account of the work of the Conference, that it is hardly necessary to say much about it. The most important thing in my mind was the choice the congress made of the refractor. In the report there is no explanation given, and no account of the discussion which took place as to the relative advantages of the refractor and the reflector. I should therefore like to explain some reasons which were at work, I believe, in the minds of my co-delegates in this matter, Mr. Christie and Mr. Gill; but they are here, and can tell you if the account I give differs from their own opinion. The reflector, I believe, is the best instrument for photography, for many reasons, one being that it brings all the rays of light to one focal plane or point. Therefore, other things being equal, there is a finer star-disc, and the whole of the light that comes from the star is effective in producing the photographic image. The extent of the field, from experiments made by Prof. Pritchard, I think, is comparable with the refractor. It is rather doubtful whether it has not exceeded that of the Bros. Henry's telescope; the star-discs were a little larger in the case of the reflector; still they retain their round shape, which is so essential to proper bisection. One of the recommendations which influenced the congress is, that the light-grasping power of the reflector is not so permanent as the refractor; and as details are of immense importance in work of this kind, that is another reason why the refractor was chosen. There is another reason, viz. the difficulty of mounting a reflector in such a way as to make it permanent. I have not the slightest hesitation in saying that if we make our reflector-discs of glass, not $\frac{1}{10}$th or $\frac{1}{12}$th of the diameter in thickness, but $\frac{1}{5}$th or $\frac{1}{6}$th in thickness, we should get rid of a great deal of injurious action. Again, we should be able to confine the mirror rigidly in its band, as rigidly as the refractor, though of course not necessarily so permanent by reason of the fact that a slight change in the mounting of the refractor does not affect the position of the image on the plate. I believe, if we were to make our mirror $3\frac{1}{2}$ or 4 inches in thickness, and if it was supported round the edge with one, two, or three bands, it would have no injurious action. Very few observers have done any work of importance with the reflector. I know that the reflector is not the instrument of the professional astronomer; and that was another reason why, in a case of this sort, where the difficulties were already sufficient, it would be necessary to give a man the instrument he was most used to. These were the chief reasons that were at work in inducing the Conference to come to the decision it did to use the refractor in this undertaking. I will just run through the week's work of the Conference. We got there on Friday, and on Saturday the Conference was opened by M. Flourens, the Minister for Foreign Affairs. The Conference got to work directly M. Flourens' speech was over, and they passed resolutions that day, and elected a special committee to sit on Monday to formulate some of the questions as to the refractor and reflector, which were accepted on Tuesday by the Conference at large. On Tuesday it was felt that the different questions of getting photographs, the kind of instrument, and all these details would be better dealt with, as Mr. Knobel has said, by the formation of two sections. Those sections sat until Friday, with the result Mr. Knobel has stated. There was a great deal of hard work to be settled, and what we could not settle we shifted on to the backs of the permanent Committee, who will be the working people, and will have to make definite arrangements. I do not, however, think that anything was shifted which could not have been legitimately shifted on to their shoulders. I do not think there was a single hard-and-fast line drawn, except, of course, the telescope and the focal length. The resolutions were made of such a wide character that the hands of the permanent Committee are not tied. They are free to take advantage of anything that may arise between now and the time they hope to get to work. That comprised the work of the Conference. It would be impossible to pass over the way that we, as delegates of your Society, were treated by Frenchmen. We were all most intensely gratified, and I feel, if we could see more of our neighbours, it would be to the advantage of ourselves and to them as well. The interchange of ideas between men who pursue a common object must result in good. I will tell you of one case. Many of the members of the Conference attended the observatory at night, and we saw, with the Equatoreal Coudé, three double stars and also Jupiter; and the conviction I came away with was, that I had been mistaken in thinking this telescope was not quite as good as the refractor. The only defect one could see was that there was a little loss of light. The image was perfect, notwithstanding that there were two mirrors reflecting the light, and those mirrors of about 10 inches in diameter. It was considered quite a difficult thing to get a plate 5 or 6 inches in diameter a few years ago, and many opticians now will be very chary of producing a plate of that magnitude. The Bros. Henry have conquered the difficulty of making these plane mirrors 14 inches in diameter, and they have one of 39 inches. They use it as a standard instrument, and you may imagine what perfection they have brought the plane mirror to. They are making, for another Coudé telescope that they have in hand, mirrors of about 2 feet in diameter.

A Fellow. They must be more than that. They will be about 40 inches in diameter.

Mr. Common. The excellence of those plates is such, that the cone of rays on the image is not perceptibly altered. That speaks enough for the perfection of the Bros. Henry's work. Touching this Coudé telescope, if any man wishes to indulge in the luxury of star-gazing in a high state of perfection, he ought to have no other kind of instrument. You need never move out of the chair; you have all the handles that work the telescope at hand, and you can do anything that a man can do with an open dome, under just the same circumstances. The heat is above the instrument, and the tubes cannot be injured by it. M. Gautier, the optician, is making these Coudé telescopes in such a way that the silver surface of the glass plane will be practically perfect. I rather feel that I owe a little apology to M. Loewy for having thought that this telescope was not the practical thing it is, and I fancy Dr. Gill will corroborate what I say with regard to the telescope. Touching the way the Frenchmen entertained us at Paris, I do not know whether you have seen the list of invitations which were given in honour of the members of the Conference, of course, to all alike—Germans, Englishmen, and foreigners of all nations. We had men from South America, from North America, from Australia, and from different parts of Europe. The list is in some of the periodicals, and I have no doubt you will read it. It is not necessary for me to go over it again.

The Astronomer Royal. I feel that, after the exhaustive and entertaining account Mr. Common has given of the Conference in Paris, I have really nothing to add, except to corroborate what he has said, especially as regards the Equatoreal Coudé. I had an opportunity of examining that, and I was quite astounded at the perfection of definition and the beauty and ease of manipulating the instrument. One sat quite at one's ease, and by means of a simple contrivance brought any object into the field of view and examined it at leisure. We examined in particular Jupiter, and the definition of the disc and of the satellites was all that one could desire. There is one great advantage in the Equatoreal Coudé which, according to M. Loewy (and I think he is right in that argument), compensates to a great extent for the loss of light caused by the two reflections, and that is that you can use a very much greater focal length than you can conveniently with an ordinary telescope. There is practically hardly any limit to the focal length of the telescope, so that it comes to somewhat the form of the old telescopes before the achromatic refractor was invented. By the use of a very long focus the chromatic aberration is much reduced, and there is a much greater concentration of light of the different colours. I think that is an important point in the optical action of the instrument. I can only add that the whole proceedings of the Conference passed off with the greatest harmony, and that we were very pleased to find there was practical unanimity as to the great work that had to be undertaken, and that there seems every prospect of its being carried out successfully to its conclusion.

Dr. Gill. I think the gilt has been taken off anything that a third speaker can say by the admirable addresses of Mr. Common and of the Astronomer Royal. I can only say that any difficulties connected with international jealousies were certainly not felt at all in the case of my own experience. Every one felt that the cause of science eliminated the differences of nationality, and that cordial cooperation in the advance of the great object in view was certainly the leading characteristic of all the discussions. One point which has not been referred to, and which, in view of the difficulty of arriving at a definite result, was somewhat kept out of sight of the congress, may, within a not very distant period, have a practical realization. I refer to a communication by M. Dunér on the new optical glass made at Jena. It was felt naturally at the congress that had we resolved to adopt this new glass we might have been committing ourselves to the indefinite postponement of the great practical work which we had met to perform, and when it was arranged and agreed that we were to deal with ordinary plates which are sensitive chiefly to rays in the neighbourhood of G, there was no absolute necessity to wait for object-glasses in which the secondary spectrum was destroyed to a greater extent than in the existing object-glasses. The facts were brought forward, and I took an after opportunity of verifying them by a visit to Berlin. The facts brought forward by M. Dunér are pretty well known, and have appeared in all the periodicals in this country, viz. that glass has actually been produced much on the lines of Harcourt and Stokes, in which the secondary spectrum of the object-glass is almost entirely destroyed. Unquestionably the problem was solved originally, and from a theoretical and, so far, in a practical point of view, by the researches of Harcourt and Prof. Stokes (President of the Royal Society). But it was reserved for Prof. Abbe and the Laboratory which has been established partly at the expense of the German Government, to carry out practical experiments which have led to the construction of object-glasses which are not only nearly free from chromatic aberration, but which are otherwise practically perfect. Professor Vogel stated, with regard to one of these object-glasses which he had examined, that the difference of the focal point for rays of various colours was one-sixth of that in the ordinary telescopes of Merz or Fraunhofer. I was so much struck with this statement, coming from a man of the influence and character of Professor Vogel, who is a well-known specialist in these matters, that I went to Berlin, and begged from a well-known optician there an object-glass of a three-inch telescope he is making for Professor Vogel, and that telescope he was kind enough to lend me. Yesterday I had the pleasure of showing that telescope to Professor Stokes and Lord

Rayleigh at the Royal Society, who thoroughly tested it by examining a well-defined dark vertical or horizontal object against a bright background, such as that formed by the top of a straight wall or vertical side of a chimney against a white cloud. By cutting off one half of the object-glass in Professor Stokes's well-known test for achromatism, you obtain an indication of the character of the chromatic aberration by a coloured fringe at the edge of the dark object. In the ordinary object-glass, as you know, an orange or yellowish-green colour appears, but with this object-glass no perceptible colour can be seen. The object-glass, for practical purposes, is sufficiently perfect. At Berlin I also observed a six-inch object-glass, which is of a somewhat different glass, but also of Jena manufacture, which is even still more perfect in colour; under very special circumstances with the 3-inch you could see something like a faint fringe, but you could not distinguish what its colour was, but in the 6-inch anything like colour was absolutely invisible. The great difficulty has been in annealing this glass. In most of the Jena glasses it is unquestionable that you can discover polarization by proper examination; but they now state that this difficulty has been completely overcome, and that they hope by-and-by to produce discs of a large size, which will enable us to overcome the last-mentioned difficulty in the construction of achromatic object-glasses. The telescope is in the hands of the Royal Society, and the secretary, Mr. Rix, assures me that if any Fellow desires to test it he will be perfectly welcome to do so. As to the general conclusions of the conference, I can only add my very cordial agreement in the remarks of Mr. Christie and Mr. Common. The whole of the conference was an unqualified success. The reception which we met with was of the most cordial character, and an example to all nations who desire to promote cordiality and good-will in the promotion of science. All national feeling was put aside, and everything was done to make us feel that we were brethren in the pursuit of a common object, viz. the advancement of science. Even should no chart result from this Conference (which God forbid!), at least there have resulted a good many friendships and much cordial feeling and good-will, which will do a great deal to promote science apart from anything else; and I think that this conference, from that point of view alone, will not have been a failure. There is one point more to which I should like to refer, as reference has been made to the equatoreal coudé. It is not good form generally to say, "I told you so;" but three years ago, in this very room, I had the honour of stating my experience in regard to the equatoreal coudé. I then gave a most unqualified testimonial, as far as my own opinion was concerned, as to its good qualities and defining-powers, and M. Loewy was good enough to say that what I had said had materially aided him in getting the means for the larger equatoreal coudé which is now being constructed, and I am very happy indeed to think that the opinions which I expressed three years ago have been so amply confirmed as they have been to-night. There are several other very interesting matters which M. Loewy is engaged in, particularly this question of his new method of the determination of aberration. It is being taken up not only by some of his countrymen, but also by astronomers in other places. I think it will prove to be a very powerful method for determination of an important astronomical constant.

The Astronomer Royal. Perhaps I may be allowed to allude to another matter which does not altogether concern the photographic conference, yet is a matter of great importance to astronomers, and that is to make the Fellows acquainted with the recent researches of M. Cornu on the regulation of clocks. He has taken up the well-known method of Jones for regulating the clock-pendulum, and has found out the source of the failure experienced in the application of that method. Jones' method consists in having a magnet fixed to the pendulum which has to be regulated, and having a coil into which it is sucked when the current from the regulating clock passes, so that that current of itself, in its passage, will draw the magnet and regulate the pendulum into a definite position. M. Cornu has found this is not a definite position, and that there is considerable variation in the action, and that, in certain cases, if the two pendulums have not exactly the same rate there may be a loss of two or more seconds. He has apparently got over this difficulty completely by putting a damper on the other side; that is, a coil of wire or tube of copper or some other metal conductor in fact, so that when the magnet on the regulated pendulum passes through it, it generates an electric current which, being converted into heat, causes friction, and so would tend to bring the pendulum to rest, and therefore the effect of the impulse which is given to the pendulum by the controlling current, which may in certain cases drive it beyond the proper point, is greatly reduced by this frictional arrangement. There are other interesting points M. Cornu has investigated in connection with this, and I think it is desirable that the matter should be brought to the notice of the Astronomical Society, as it seems that astronomers will be thus enabled to keep a regulated pendulum in perfect synchronism with the regulating-clock.

Mr. Knobel. I would like to remark that the French astronomers have been quick to seize hold of the enormous advantage likely to accrue to astronomy by the preparation of a photographic chart of the heavens; and the French Government have shown their anxiety to promote astronomical science by cordially and generously granting the necessary funds for four of their principal observatories to take part in the work. I believe that we in England, particularly at the Royal Astronomical Society, sympathize to the utmost with this great work that it has been decided to undertake, and I do not think that we shall be lacking either in our sympathy or our efforts to obtain the cordial cooperation of this country with the operations that have already been decided on by France and other countries.

Dr. Gill. May I say one word more about a clever invention of our French neighbours exhibited to us in Paris? One of the subjects which has most occupied astronomers in recent days has been the question of photometry, and M. Cornu has produced a photometer which promises to be one of the most accurate yet invented. There are many forms, and in its simplest form it is applied to a divided object-glass. The object of this photometer is to observe the eclipse of Jupiter's satellites. It is quite evident that if the segments of the heliometer object-glass are brought into coincidence with their optical centres, you get an ordinary image of Jupiter and its satellites. The first thing you would do would be to separate the segments of the object-glass so as to produce a double image of Jupiter and his satellites, so that the image of one of the satellites not eclipsed is brought into close conjunction with the image of the satellite which is being eclipsed. You would also introduce a little screen in the field of view to obliterate the image of Jupiter. Therefore the only things visible would be the satellite about to be eclipsed, and the satellite which is not to be eclipsed. Suppose this satellite is becoming less brilliant by progress of eclipse, how shall we equalize the images? We reduce the image of the brighter one and increase the brightness of the image of the fainter one. That is simply done by a screen which has an aperture smaller than that of the object-glass, and which is moved across the object-glass at right angles to the line of section of the segment. That is very pretty! How will you measure that? You simply attach a pointer, which moves along a barrel which is turned by clock-work, and whose axis is at right angles to the line of separation of the segments. The motion of this slide is made by a pen upon the surface of the chronograph barrel. The time is written down by a little chronograph pen, so that all the observer has to do while matching the eclipsed and non-eclipsed satellite is to turn a handle which moves the slide across and across until he has equalized the brightness of the images, and then to touch a button, and it writes down immediately the relation of the area of the two segments, and the time at which the observation was made. The whole of the practical observation, therefore, consists in the turning of one handle until the two images are equalized in brightness, and the pressing of a button which causes a complete record to be made. There are developments in this apparatus which render it applicable to an ordinary telescope instead of the heliometer; but it would be too long for me now to enter into the subject here, particularly as M. Cornu has published, or is about to publish, an account of the instrument in detail; but I think it is right I should draw attention to it.

Mr. Sadler. The lights transmitted by the two segments of the heliometer are equal?

Dr. Gill. That is a question for study. The constants of the light-ratio have to be determined.

Mr. Sadler. It is not a case of direct determination?

Dr. Gill. No; it is a question for study.

The President. I am sure the Society will thank our delegates for having gone to Paris to represent us at this important Congress, and also for the extremely interesting and valuable communications which they have made to us to-night of the wonders they saw there. I can only echo what our Secretary has said, that I hope this country will not be behindhand in the carrying out of this new chart of the heavens. I can also say that the Council have to-day, at their meeting, been considering the best means by which they can ensure the carrying out, both in this country and in the colonies, the work which is required to complete the share which naturally would fall to this country in this new photographic chart of the heavens.

Mr. Green then proceeded to read a memoir upon the planet Jupiter, which he stated to be the result of 27 years of work and careful study of the planet. The headings of the memoir were as follows:—In Chapter 1 was a chart of the markings of Jupiter from 1860 to 1887, a view for each year, showing the remarkable changes through which the planet had passed during that time. In the second chapter was shown the connection between light and dark bands; in the third, the connection between small markings of light and shade; in the fourth, the relative altitudes of light and dark markings; and in the fifth, the great red spot was treated of. The memoir was the result of the examination of an extended series of drawings from 1859 to 1887. During some favourable oppositions more than a hundred views had been obtained, but on all occasions a sufficient number had been secured to record the general appearance of the planet. The intention in continuing the series during so many years had been to gain a knowledge of those more permanent conditions which had been maintained through several oppositions, and of the laws which appeared to govern these changes. The chart exhibited the general appearance of Jupiter for twenty-six years, during which time the planet had passed through several well-defined periods of change, each period being marked by considerable alterations affecting the greater portion of the disk. During the period from 1860 to 1868 the equator was occupied by a band of white, edged with dark belts, in both hemispheres. In the period from 1869 to 1872 the equator was of a decided coppery hue, the north and south belts moved towards the poles, and were greatly reduced in breadth. The third period, from 1873 to 1878, was marked by the appearance of a multitude of most delicate markings in the southern hemisphere, and by a reduction of the coppery colour of the equator, which towards the end of this period settled principally in the northern belt near the equator. In the fourth period, from 1879 to the present date, the planet had exhibited most perplexing changes of colour and of form. The second chapter was taken up with the question of the connection between light and dark belts. The northern dark belt was connected with a white belt next it. For many years there had been no separation between them, whether the dark belt remained stationary or whether it had migrated to the south. He had been so struck with the number of times that the strongest dark and the strongest light belts were found together, that he had taken a percentage from the whole number of drawings, and as he made sometimes a hundred drawings in a year, and occasionally a hundred and fifty, it would be seen that the number was considerable. The percentage came out somewhat in this way: instances of connection between strongest light and strongest dark, 87; instances of separation, 5; doubtful instances, 8; total 100.

Mr. Green then proceeded to consider the connection between lights and darks. A small mark of light did not exist by itself, but was, generally speaking, to be found surrounded by an amount of dark. Generally speaking, a certain quantity of light was to be found in connection with a certain quantity of dark underneath it. He did not deny that in many cases it might be that the connection was a mere optical illusion. Mr. Green also considered the question of the altitude at which these markings were found. The question of the colour of the markings, which were sometimes orange, or grey, and even greenish, together with many other points, were also considered in the paper. Coming to the great question of what is known as "the great red spot," Mr. Green described it as a red mark surrounded by a white mist, and proceeded to refer to the changes which he had noticed in it over a period of years. The remaining portion of the paper was occupied with the conclusions at which he had arrived. The general conclusion was that Jupiter was surrounded by an atmosphere containing a large amount of suspended moisture, which was condensed under varying circumstances into forms greatly resembling those on our own planet, and though these forms were constantly changing, they occasionally displayed considerable permanence. While he thought that Jupiter might retain a large amount of original heat, it was not to any extent incandescent, and this view was supported by the fact that all the great visible changes were confined to spaces extending for forty-five degrees on each side of the equator, or to that portion most under the influence of the Sun, whereas the poles and temperate zones were comparatively at rest, a state which would ill-accord with the presence of light-giving fire or heat. With regard to the number of times that the light-belt was to be found on the polar side of the dark one, he had also taken a percentage. In the opposition of 1872 fifty drawings were made. In these there were over sixty instances of the light-belt being on the polar side. That was a greater number than the drawings of it, but of course it referred both to north and south. In the opposition of 1882–83 in over one hundred drawings there were no less than ninety-three instances, particularly in the south. In 1885, when 156 views were taken, the same thing occurred 210 times, showing that this was a feature of very permanent character, the great number being in consequence of the fuller development of both the north and the south systems of belts. The white belts he attributed to the condensation of moisture raised from the surface of the planet on the equatoreal side. With regard to the various colours, he concluded that they represented portions of the planet seen through openings in the clouds. The delicate gradations of colour might, he thought, be due to varying conditions of transparency. Mr. Green concluded by observing that it had always been his intention that the drawings of the planet Jupiter should belong to the Society, and therefore it might be that in the future some Member of the society would pry over them in order to see what was the state of Jupiter in those days.

Mr. Knobel. I should like to ask Mr. Green a question with regard to these dark spots being in connection with light spots. He has shown them always on the following side of the light spots. Has Mr. Green noticed those dark spots equally on the preceding side? This question was brought before the Society some years ago, I think by Mr. Brett, of the dark marking being in proximity to light spaces, and a theory was started by him to explain it. I myself had noticed the same thing in the same opposition. But in my own case I had always noticed that the dark marking or dark shade was always on the following side of the light space. I should like to ask Mr. Green if he has observed the dark markings on the preceding side of the light space, and also if he has noticed any difference before or after opposition.

Mr. Green. With regard to that, the general position of the dark mark has certainly been on the following side. I cannot say I have noticed any particular difference in it before or after opposition.

Mr. Knobel. My remark has reference to Mr. Brett's paper on the subject.

Mr. Green. I do not recollect having observed anything of the kind.

Capt. Noble. Mr. Brett noticed a case where the shadow fell both ways.

Mr. Green. It would be very easy to explain these markings if you consider these dark spots to be portions of the underlying surface of the planet, and the light spots to be isolated, or comparatively isolated, tracts of condensation passing from the equator towards them.

Mr. Knobel. I think this is the first instance of these spots being suggested as elevations since the idea was first broached by Mr. Brett. I think it is rather important. I should like to hear Mr. Brett express his views about it.

Mr. Brett. I would remind you, Sir, that my object then was to point out that the dark in proximity to the light globule was most visible in quadrature. That is how I set out to establish the fact that they were shades. When the planet was in opposition you would not see them,

The President. The Society have already thanked Mr. Green for his paper. I will call upon Mr. Sandford Fleming, whose name is well known in connection with universal time, to make a few remarks upon that subject.

Mr. Sandford Fleming. When I came to London a few weeks ago I did not expect to have the pleasure of being present at a meeting of the Royal Astronomical Society, still less did I expect to be called upon to speak before the Society. The subject you have been good enough to associate my name with is a very commonplace one compared with the very various subjects discussed here; and if I attempt, as one of the pioneers of civilization in a distant country, to say a few words on that subject, I must crave your kind indulgence. In Canada we have been endeavouring for some time past to establish improved means of communication, which I trust will be of service to the Empire at no distant date. We began by building a railway first from Halifax to Quebec, and more recently from Quebec to the Pacific shore, and with those lines of communication I have had something to do. In connection with those lines I found that trains would have to run by all sorts of times. This is easily understood when I bring it to your recollection that Halifax is some 60 degrees of longitude different from Vancouver's Island on the Pacific coast. Each city you pass through having its own time, and each town as it rises up having a still different time, would occasion great difficulty. The other difficulty I think you are familiar with here. The day is divided into two halves: I mean the civil day; the astronomical day is not the same. We found much confusion not only in Canada, but in the United States, where the railway system is developed to a great extent, in connection with the hours of forenoon and afternoon. We found greater confusion likely to result unless we could effect some change. In Canada we studied the matter, and we found that by adopting what is known as the standard hour system—that is to say, a time for certain zones separated by 15 degrees of longitude—we would have a leap from hour to hour, but the minutes and seconds would be the same throughout the country. This was, then, the way in which the difficulty was overcome in the United

States. The people of the two countries, or rather the managers of the railways met, and they decided to adopt the hour system some two years back. That system has been adopted; it was objected to in a few quarters, but in those quarters they are now coming to see the advantages resulting from the common adoption of the system; and on the continent of North America we have now practically only four standards of time in place of a countless number. The second difficulty, or the division of the day into two halves, has been surmounted, at all events some progress has been made. On the Canadian Pacific Railway, and on some branch lines, the 24-hour system, as it is called, was adopted last year. The manager issued time-cards with the hours numbered from midnight to midnight, in place of midnight to noon and noon to midnight. This has been in use for nine months. The officials of the railway readily fell into the new system, and the people who live on the line fell in with it, so that the 24-hour system has been adopted practically by all on those 2000 miles of railway. So successful has it proved, that the Pacific Railway Co. has determined, when the next time-cards are issued, to carry out the same system throughout the whole extent of the railway, covering possibly 4000 miles, and many of the branch lines are doing the same. There are various societies in the United States and in Canada who are promoting these changes. There is the Society of Civil Engineers in New York, an American Society, a body similar to the one in this city; the Metrological Society of America, the American Society for the Advancement of Science; the Canadian Institute; the Royal Society of Canada, and others. They are all endeavouring to bring about the change which is felt to be needed. But we look forward to a still greater change. We think that at no remote period we shall have one time in place of the four or five times. We trust that the British Colonies, Australia and the Cape of Good Hope, and also India, will take this matter up, and render it quite easy to adopt universal time in those countries as well as in the United States and Canada. Having adopted the hour system, which system, as you are doubtless aware, is in perfect harmony with the time at Greenwich, it will be a very easy matter indeed when the proper time arrives—possibly 10 or 12 or 15 years from now—to adopt universal time throughout the globe.

Capt. Noble. There is nothing more interesting in what Mr. Sandford Fleming said than that portion of his speech in which he referred to the fact that over a distance of 2000 miles the 24 hours' reckoning of time had been adopted, and that the people had taken to it kindly. When I have, as I have for a long time, advocated the adoption of that mode of reckoning in England, it is said, "Oh! people will not take to it; they will not do it." My belief is that the people of England, like those of Canada, would soon fall into the system of the 24 hours' reckoning, and would wonder how on earth they had been content with a system by which, as has been said, a man might find himself at a station 12 hours wrong to meet a train; which happened to Prof. Adams at Cambridge.

The following papers were also announced:—

Lt.-Col. Tupman. "Occultation of α Tauri, 1887, March 2."

Maxwell Hall. "The Sidereal System, revised in 1887."

J. Tebbutt. "Observations of Saturn and δ Geminorum, Jan.–Feb., 1887."

W. H. Finlay. "On the probable Errors of Transit-observing."

Capt. E. J. Malony. "Sextant Observations of Comet *a* 1887."

Dr. J. Morrison. "The Orbits of Comets Fabry and Barnard-Hartwig."

Dr. J. Morrison. "Ephemerides of the Satellites of Mars during the Oppositions of 1888 and 1890."

W. H. S. Monck. "On the Inclinations of Cometary Orbits."

Rev. S. J. Johnson. "Note on a MS. Eclipse Volume."

J. L. E. Dreyer. "Note on the effect of Refraction in Stellar Photography."

E. Neison. "On Prof. G. W. Hill's paper on Delaunay's Method."

R. Bryant. "On the Orbit of Comet II. 1883."

A. Marth. "On the Formulæ for correcting approximate Elements of the Orbits of Binary Stars."

H. Lefavour. "The Right Ascensions of certain Stars within ten degrees of the Pole reduced from observations by F. G. W. Struve."

J. L. E. Dreyer. "On some Nebulæ hitherto suspected of Variability or Proper Motions."

The following gentlemen were duly elected Fellows of the Society:—

Dr. Gustavus William Nicholls, Pernambuco, Brazil; W. Austin Ashe, Director of the Observatory, Quebec.

The meeting adjourned at 9.50 P.M.

Liverpool Astronomical Society.

The eighth and last general meeting of the Session was held on Monday, May 9th, Mr. Walter Sang, in the chair. Thirty-eight members were elected, and Dr. L. da Rocha Miranda, of the Imperial Observatory, Rio de Janeiro, was elected an honorary Associate of the Society.

In a note on the solar eclipse of Aug. 1886, the Rev. S. J. Johnson mentioned that as the greater portion of the total phase could only have been observed on the ocean, he had been induced to make inquiries of the different lines of steam and sailing vessels, for the purpose of ascertaining whether any observation of totality had been secured, but his applications had hitherto not met with success. Capt Owen, of the Union-Line steamer 'Pretoria,' obtained seven negatives of the partial phase only, his ship being at the time about 520 miles S.E. of St. Helena. Mr. Johnson suggested the desirability of further inquiries being prosecuted in this direction, as it was quite possible that some Liverpool vessels may have been in the line of totality, and that matters of interest in connection with the total phase may have been entered in their log-books.

In a paper entitled "Stellar Influences on Physical Geography," Mr. W. H. S. Monck said that a paper which he had read before the Society some time before on the possible effect of terrestrial heat on the Moon had naturally suggested the question to his mind as to whether the Earth itself might not in past ages have been subjected to similar influences, the effect of which we might be still experiencing. Such a source of heat could, of course, only have had its origin in one of the fixed stars. The rate of motion of our planet round the Sun was from 18 to 20 miles a second, rather under than over the average velocity of those stars whose motions of approach or recession have as yet been determined by means of the spectroscope. In 50 millions of years, a star travelling at the same rate as the Earth would have moved over a space which light would take some 5000 years to traverse, and it is possible that the distance of very few (if any) of the 70 millions of stars within the range of our most powerful telescopes exceeded 5000 years' light passage. Hence it was possible that any, or every one, of these 70 millions of stars, supposing their proper motion was suitable, may have visited our solar system within the 50 millions of years which the great majority of geologists consider have elapsed since the earliest dawn of life on our globe, or, as our solar system has a proper motion in space which is not estimated by any astronomer at a value less than one-fifth that of the Earth's motion round the Sun, our system might in the same way have come within the influence of some one of these fixed stars. To the objection that such an approach would have deranged the stability of the planetary orbits, it might be urged that an intensely hot star might approach near enough to affect our climate without

lly deranging our motions. The effect produced would [illegible]
be greater if our visitor was not a single star but a star [illegible]
The writer considered that the evidence of [illegible]
n past ages tended to bear out this hypothesis.
A. Stanley Williams contributed a paper on "The [illegible]
s of the Markings on Jupiter." He mentioned that during [illegible]
t few weeks there had been very large and [illegible]
gs visible, which exhibited in a striking manner the [illegible]
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other hand, an oval white marking on the [illegible]
uble north equatoreal belt had a [illegible]
the same as that of the [illegible] red spot, which differed
erably from that of the light and dark spots [illegible]
are also other markings situated in different latitudes [illegible]
of which had not been satisfactorily ascertained. [illegible]
ns's paper was illustrated by two drawings made with [illegible]
his 6½-in. Calver reflector.
ringing his series of articles on "Telescopes and [illegible]
" to a conclusion, Mr. W. F. Denning [illegible]
importance and attractions of its subject [illegible]
ntly evidenced by the gaining popularity [illegible]
erse fields of astronomy. As regards the [illegible]
copes and telescopic work, the outlook was [illegible]
Several very large telescopes had [illegible]
them being the 30-in. refractor at [illegible]
more were under construction. The [illegible]
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urst, London, Sunderland, Bristol, and [illegible]
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wever, reveal any other duplicate [illegible]
e meteor beyond the three [illegible]
sly described.
xhaustive report of the lunar section [illegible]
nd included thirty drawings of [illegible]
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of that formation. The [illegible]
and the ring-plain [illegible]
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ollowing is a list of the [illegible]

by the Council to serve on the executive :—*President*, Mr. Denning; *Vice-Presidents*, Messrs. Elger, Espin, Gore, and Newall; *Special Observer*, Mr. Gill; *Editor*, Mr. Sadler; *Librarian*, Mr. Defieux; *Secretary and Treasurer*, Mr. Davies; *Council*, Miss E. Brown, Messrs. Backhouse, Calver, Deane, Gill, Higgs, Lynn, Monck, Oliphant, Tarrant, and Majors Markwick and Watson. The Directors of Sections are :—Solar, Miss Brown; Lunar, Mr. Elger; Double Star, Mr. Tarrant; Coloured Star, Mr. Franks; Variable Star, Mr. Gore; Mr. Denning directs the Comet-seeking, Meteoric, and Jupiter Sections.

The Secretary announced that the Meetings would in future be held at the Royal Institution, Colquit Street. The Session was then formally closed.

Selenographical Notes.

Unrecorded Rills, near Burg, Lee, and Herigonius.—The following observations have recently been received from M. E. Stuyvaert, of the Royal Observatory of Brussels. At 10^h 45^m on 17th October, 1886, when the West long. of the evening terminator was about 27° 45′, the rills east of Burg were favourably placed for examination, but exhibited a very different arrangement from that shown both by Neison and Schmidt. The most conspicuous member of the group (1) follows a zigzag course from an isolated peak north of the ring-plain, to the little crater Burg B on the eastern border of the Lacus Mortis. From the northern wall of Burg a short rill (2) extends to a second mountain-peak rising some distance to the east of the formation, and with a short break, caused apparently by the interposition of this feature, bends towards the south, terminating amid the mountains a little east of Plana C. Both Beer and Mädler and Schmidt draw a ridge on the site of this cleft. On the north-west side of the plain traversed by these objects, M. Stuyvaert has also seen two other rills (3, 4), crossing each other nearly at right angles. One of these runs from south-west to north-east, and the other extends in a curve, convex towards the east, from a point a little north of the mountain-peak referred to in connection with 1, and nearly joins the first rill about the centre of the plain. A fifth rill was traced on the east side of the Lacus Mortis, from a spur in the border to a point near the headland, marked B in Neison (Map v.). It may be noted that, with the exception of 1 and 4, these objects are not shown either by Schmidt or Neison (Mädler draws no rills in this neighbourhood), and there is a material want of agreement in their several representations.

At 10^h on 5th March, 1887, when the morning terminator lay a little east of Doppelmayer, a rill was observed in the hilly region south of Lee. It was traced from a ridge north-east of Vitello *d*, following an "S" curve, up to a spur projecting from the south-eastern barrier of Lee. There are no indications of this object in any lunar map, Schmidt showing merely two or three wide parallel valleys in this position.

At 11^h on the same evening, M. Stuyvaert detected a delicate rill between Gassendi and Herigonius. On the border of the Mare south of Letronne, there is a partially ruined circular plain, with a wide opening towards the north-west. The rill in question was traced from near the peak Δ (Neison, Map xii.), which stands on the south-west side of the plain, across the opening to the west side of a long ridge north of the plain. Its general direction is towards the north, and it follows a very serpentine course throughout. Neither Schmidt nor Neison show this object in their maps or mention it elsewhere. I have received, however, a sketch of this region, made on 12th June, 1886, by Mr. Davis of Theale, near Reading, in which a short rill is drawn, passing through a small crater east of Herigonius E, and agreeing very fairly, as regards position, with that just described. M. Stuyvaert's observations were made with the equatoreal, of $0^m{\cdot}38$ aperture, attached to the observatory, a magnifying-power of 260 being employed.

Kempston, Beds, 1887, May 19. THOS. GWYN ELGER.

Meteor Notes.

ON April 25, in a watch of $5\frac{1}{2}$ hours between $9\frac{1}{2}^h$ and 15^h, 28 meteors were recorded. The shower of Lyrids which had been seen on the 18th, 19th, and 20th 'Observatory,' May, p. 189) had become quite extinct, and an active display from 272° +21° appeared to have succeeded it. On April 26, between the clouds, I observed a few other meteors, and these, taken in combination with those noticed on preceding nights, gave radiants at 254° +57°, 260° +62°, 280° +47°, and 302° +23°. But the showers of this epoch are apparently more remarkable for their numbers than for individual richness, and they can only be satisfactorily determined when the observations are numerous.

On April 25, at $13^h\ 3^m$, I saw a very slow bright meteor, with yellowish disk and train, moving from 297° +58½° to 328° +42½°; duration 5½ seconds.

Between May 9 and 13 I observed 25 meteors; but the number was insufficient to indicate any good radiants.

Fireballs.—On May 7, at $9^h\ 37^m\ 50^s$, Mr. J. L. Stothert, of Bath, noticed a very fine, fast-moving meteor traversing a path from about E. by S. to W. by E., declination probably 5° N. of equator. Brilliancy equal Venus at the present time.

On May 8, at $8^h\ 22^m$, one of the largest meteors which have appeared of late years was observed at many stations in the southern parts of England. It was seen in the dusk of early evening before 2nd-mag. stars could be discerned, and was many times brighter than Venus. As the fireball slowly descended it was fringed with an intense blue light, and cast off a train of red sparks. At extinction the nucleus seemed frittered into a dense stream of red particles. Many persons who witnessed the phenomenon were surprised at its brilliant effect, at its apparent proximity, and at the time it remained in view.

Descriptions of this meteor have been received from Eastbourne, Stafford, Staines, Hartfield (Tunbridge Wells), London, Watford, Clevedon, Bristol, &c., &c. From a discussion of these it is apparent that, when at its brightest near the end point, it was situated over a point of the Earth's surface slightly north of a line joining London and Bristol. Observers at the former place saw the meteor descending below Venus in the west, while at Bristol it fell in the east considerably to the right of Vega, after traversing the stars of Hercules not then visible. At Stafford it was carefully observed between S.S.E. and S. by E. pursuing a course of 12° from about $288\frac{3}{4}^\circ -13\frac{1}{2}^\circ$ to $286^\circ -25^\circ$.

A considerable number of the descriptions relate to the latter part of the meteor's flight; but the place of first appearance is indicated by several observers who obtained a good view of the whole course. At Stafford the meteor was seen much foreshortened near its radiant-point; and this observation is important, as the other records are all from stations considerably E. or W. of the meteor's track.

The first appearance probably occurred when over a point in the English Channel, in lat. 50° 21′ N., long. 0° 50′ W., or about 25 miles S.E. of the Isle of Wight, when the height of the fireball was about 70 miles, and it disappeared a few miles N. of Swindon, at a height of 14 miles. Length of path 110 miles. It was directed from a point 24° E. of S., and fell towards the Earth at an angle of 30°. The radiant is indicated at $191^\circ -5^\circ$, and earth-point near Winchcombe, in Gloucestershire.

The velocity of the fireball is to some extent doubtful, as the estimates are conflicting; but it would certainly appear that the whole duration was more than 6 seconds, in which case the speed would be less than 18 miles per second. As to the real dimensions of the nucleus, this can hardly be surmised, because it is impossible to discriminate what extent of the flaming ball constituted the actual diameter. It was probably very much smaller than its magnificent effect would presuppose. One observer at Bristol compares its size to a tennis-ball, another says it was as large as his fist, while a third mentions it as equal to a "good-sized turnip!" This reminds one of a description in the 'Report of the Chief Signal-Officer,' Washington, 1881, p. 786, where the statement is made that, on June 30, 1880, "about midnight a brilliant meteor appeared near the zenith like a great mass of fire as large as a barrel and whirling in the air."

The radiant of the fireball of May 8 does not accord with any well-determined meteor-shower. It could hardly have been associated with the fireballs of 1878 May 12 and 1880 May 2, which belonged to a stream at 214° −7° in the W. boundaries of Libra.

The most noteworthy feature of this fireball was its great lustre at a time when daylight was still very strong. Several of the observers first noticed a bright flash, and looking up saw the end of the meteor as it finally dispersed itself in a confused mass of red sparks. The brightness was estimated by one person as much exceeding that of the full moon, and, had the effect been witnessed on a dark sky, it must have been far more striking.

On May 9, at $8^h\ 58^m$, a bright meteor, much exceeding 1st mag., was seen here in the twilight, falling from about 252° +10° to 265° +2½°. This probably belonged to a radiant in Boötes.

Bristol, 1887, May 17. W. F. Denning.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Motion of Jupiter's Red Spot.

Gentlemen,—

In the following short list I have compared two observations secured here early in the opposition with several obtained more recently. On all occasions a 10-inch reflector, power 252, was employed.

Date.	Red Spot observed central.	Spot precedes Marth's zero-meridian.
1886, Nov. 23	$19^h\ 34^m$	$2^m·8$
Dec. 17	19 25	5 ·9
1887, May 7	10 31	15 ·5
May 9	12 9	15 ·5
May 10	8 2	13 ·8

These figures prove that the spot, instead of slackening its motion in conformity with its behaviour in previous years, has now apparently commenced an increase of speed; but it will be advisable to wait until observations are further extended before finally determining the extent of the acceleration. Between Nov. 23, 1886, and May 10, 1877, the spot completed 405 rotations with a mean period of $9^h\ 55^m\ 39^s$, which is more than 2 seconds less than that derived from the last opposition ($9^h\ 55^m\ 41^s·1$). This result accords with Mr. Williams's notes ('Observatory,' May 1887, p. 193).

The spot is still somewhat faint, though readily distinguishable on a good night. The central part is not very obvious, but the surrounding red ellipse may be definitely traced though subject to some irregularities, rendering certain portions plainer than others. The following end is now the most pronounced; and it was recently noticed by several observers that it formed a junction with a dark belt to the east, but at the present time the spot appears quite detached from outlying belts. Yours faithfully,

Bristol, 1887, May 15. W. F. DENNING.

Comets and Asteroids.

GENTLEMEN,—

I think Professor Kirkwood's short note on this subject, a summary of which appeared in the 'Observatory' for this month, is well worth the attention of astronomers, and that the theories of Schiaparelli, who refers most of the comets of short period to capture by Jupiter, and of Mr. Proctor, who explains them by emission from Jupiter, must be abandoned for one which connects them with the asteroids.

The comets in question evidently form a numerous class. Additional members are constantly being discovered, and others will no doubt be added. They present the following characteristics:—

1st. Their mean distances (and consequently their periods) and the inclinations of their orbits to the ecliptic agree with those of the asteroids, both being apparently confined within the same limits. The mean distance always exceeds that of Mars and falls short of that of Jupiter, while the inclination, I believe, never exceeds that of the orbit of Pallas (except perhaps with Pigott's Comet of 1783).

2nd. The motion of all these comets, like that of the asteroids (and planets), is direct.

3rd. They are all small comets, few of them being visible to the naked eye, even when nearest to us.

4th. Their orbits are considerably less eccentric than those of other comets.

I do not think that either the theory of capture or that of emission will account for these peculiarities.

When we pass beyond this class of comets we at once experience a change. That of Tuttle (whose mean distance and period probably approach most nearly to those which I venture to term asteroidal comets) has its orbit inclined to the ecliptic at an angle of over 54°. The next, perhaps, is the comet of Tempel, which is well known as the source of the Leonid meteors. Its motion is retrograde, and so is that of Halley's Comet and of the comet of Peters, to which a period not much exceeding that of Jupiter has been assigned. The Pons-Brooks Comet and some others of comparatively short period have their orbits inclined at a high angle to ecliptic. In short, the combination of features above mentioned is peculiar to the class of comets in question.

I may add that the aphelion of Encke's Comet lies considerably within the orbit of Jupiter. This, however, is not decisive against the theory of capture or even of emission, since the axis major of this comet's orbit is known to be shortening.

Whether a small asteroid exposed to the perburbation of Jupiter, arising from the commensurableness of their periods or from the unusual closeness of its approach, might not break up into a comet with attendant flight of meteors, is another question. The force of gravity on such an asteroid would be very small; and if its parts were not held together by some other cohesive force, ultimate disruption might not perhaps be improbable. I hope Professor Kirkwood will follow up his suggestions on this subject.

Truly yours,
Dublin, 1887, April 29. W. H. S. MONCK.

Examination of Stellar Photographs.

GENTLEMEN,—

With reference to Mr. Backhouse's letter in the current No. of the 'Observatory,' permit me to mention that, at the recent Paris Conference, M. Cornu recommended the stereoscopic method for comparing two photographic plates of the same region of the heavens, so as to readily reveal any differences; and he exhibited such an apparatus, which he had specially devised for the purpose.

Your obedient Servant,
Braintree, 1887, May 5. EDWARD B. KNOBEL.

L'Anneau de Saturne.

MESSIEURS,—

Je dois appeler l'attention des lecteurs de l'*Observatory* sur un changement important que je crois avoir remarqué dans l'aspect de l'anneau B de Saturne, le 8 mai, à 8^h 30^m, t. m. de Bruxelles, à l'aide du grossissement de 280 fois de mon équatorial de 8 pouces de Grubb. En décembre 1886, janvier et février 1887, la partie extérieure de cet anneau seule était très brillante, contre la division de Cassini, et la partie intérieure était excessivement sombre. Le 8 mai, au contraire, tout l'anneau B était éclatant et c'est à peine si l'on voyait encore une trace de la région plus sombre contre l'anneau C. Malgré l'éloignement de la planète je voyais la division de Struve, surtout à l'ouest, et cette fois il était manifeste qu'elle laissait une zone étroite de l'anneau obscur à son extérieur. Je n'avais jamais aussi bien vu la transparence de l'anneau obscur et la division d'Encke se montrait encore sur l'anse orientale. Tous les détails observés précédemment sur le globe étaient encore visibles et aussi la dentelure noire de l'ombre sur la division Cassinienne, mais cette dentelure était devenue plus petite et l'ombre avait cette fois un bord convexe concentrique à peu près au contour du globe.

Je vous prie, Messieurs, de me croire

Votre bien dévoué,
Louvain, le 10 mai, 1887. Dr. F. TERBY.

La Tache Rouge de Jupiter.

MESSIEURS,—

Hier soir, 10 mai, à 9^h, j'ai observé la tache rouge de Jupiter avec le *grossissement de 280* fois de mon équatorial de Grubb; la tache a perdu sa teinte caractéristique et apparaît comme un nuage ovale blanc, limité par une bordure grise elliptique ; cette bordure est moins marquée à l'ouest. L'extrémité orientale de la tache a passé au méridien central vers 9^h, t. m. de Bruxelles. Le ciel légèrement nébuleux a empêché d'utiliser toute la puissance du réfracteur, mais l'image offrait néanmoins une grande richesse de détails très délicats. A 8^h 30^m j'ai pu confirmer encore le changement d'aspect que je vous ai signalé dans l'anneau B de Saturne.

Votre bien dévoué,

Louvain, le 11 mai, 1887. Dr. F. Terby.

The Great Comet of 1825.

Gentlemen,—

The great value, as a work of reference, of Dr. Carl's 'Repertorium der Cometen-Astronomie' induces me to ask you to call attention to an erratum in it which I have detected in his survey (p. 184) of the observations of the great comet of 1825. That comet was discovered by Pons at Florence on the 15th of July, and at first supposed by him to be an apparition of Encke's comet. It was independently discovered by Biela at Josephstadt on the 19th of that month; and ten days afterwards by Dunlop at Paramatta. The observations extended over very nearly a year, the last observation having been made by Inghirami (then Director of the old Observatory there) at Florence, on the 8th of July, 1826 (Astr. Nach. vol. v. p. 150). Dr. Carl gives the date of the last observation as August 11, inadvertently attributing Inghirami's observations of the comet discovered by Pons on the 7th of August, 1826 (extending from August 8 to 11), to the comet in question.

Yours faithfully,

Blackheath, 1887, May 11. W. T. Lynn.

First Discovery of the Great Nebula in Orion.

Gentlemen,—

Although when Huygens observed this object (which he calls "Portentum, cui certe simile aliud nusquam apud reliquas Fixas potuit animadverteri") in the year 1656, he evidently supposed that he was the first person who had noticed it, and the first discovery has been attributed to him in a large number of astronomical works (after Halley in that earliest of all catalogues of nebulæ which was published by him in the 'Philosophical Transactions' for 1716), it is now well known that the nebula in question was noticed by Cysat, of Lucerne, in the year 1618, or thirty-eight years before it was perceived by Huygens. This was pointed out by Prof. Wolf of Zürich in the year 1858 (see vol. i. of his 'Biographien zur Kulturgeschichte der Schweiz'), so that it is somewhat strange to find some books and treatises of reputation —such as that on 'Astronomy' in the present (ninth) edition of the 'Encyclopædia Britannica—still ascribing the discovery to

Huygens. Cysat's account of it is given in his work on the comet of 1618, which was published at Ingolstadt in 1619; and as that treatise is somewhat rare, it may interest some of your readers to give the quotation from it. Describing the head of the comet, he compares it, on the 1st and 4th of December, to the nebula in Andromeda; but on the 8th of that month he found that its appearance was as if it had separated into three or four points of light, cohering together and reminding him of the "comites" or companions of Saturn. (This of course was before the discovery that these appendages were of the nature of a surrounding ring, Cysat's idea of the ansæ being the same as that of Galileo.) These points of light afterwards increased in number, and on the 24th of December appeared to be very numerous. Cysat then compares the comet's head to the nebula in Orion in these words:—

"Cæterum huic phænomeno similis stellarum congeries est in firmamento ad ultimam stellam Gladii Orionis, ibi enim cernere est (per Tubum) congestas itidem aliquot stellas angustissimo spatio et circumcirca interque ipsas stellulas instar albæ nubis candidum lumen affusum, hæc inquam congeries stellarum Capiti Cometæ simillima est, nisi quod aliquanto oblongior."

Yours faithfully,

Blackheath, 1887, May 1. W. T. Lynn.

The Variable Star Lalande 10063.

Gentlemen,—

The star Lal. 10063, which is suspected of variability, has been observed several times recently at this Observatory. The dates and estimated magnitudes are given below; also the estimate of β Leporis when it occurred in the same zone.

Date.	Mag. of Lal. 10063.	Mag. of β Leporis.
1885, Feb. 2	5	4
Dec. 11	5	3
1886, Jan. 1	6	—
7	5	3
22	5	—
Feb. 8	6	—

From this it will be seen that the star was distinctly fainter than β Leporis.

Lalande gives the magnitude 5½; Bonn vi., 6; Radcliffe 1883, 5; Cordoba, 4·9. These magnitudes do not vary more than would be readily accounted for by different states of the atmosphere and personal errors. If the star was equal to β Leporis in brightness last June, there must have been a temporary increase of light.

Yours truly,

J. G. Porter.

Cincinnati Observatory,
Cincinnati Ohio, 1887, April 13.

Proposed Nomenclature for Star-colours.

GENTLEMEN,—

I have not seen any criticisms or suggestions with reference to Mr. Franks's proposal in the March No. of the 'Monthly Notices,' so I venture to make the following remarks in the absence of any from those more qualified to speak on the subject.

I think the principle of the method proposed by him is a good one, and probably his diagram is sufficiently exact for practical purposes; but I would point out that the colours he has placed as complementary to one another are not strictly so, as, for instance, the complementary colour to red is a bluish green.

I do not think that the colours between blue and red are rightly named. I understand violet to be a bluish purple; and therefore if violet is used as one of the principal colours, the intermediate tint between it and blue should be called bluish violet. If the term "bluish purple" be retained, then *purple* should be used instead of "violet;" and I should be inclined to consider purple the more suitable colour. I see, however, that Prof. O. N. Rood, in 'Modern Chromatics,' who has given on p. 214 a very similar, though admittedly rough, diagram to that of Mr. Franks, has placed violet in this position, as the latter does. (A great deal of information is contained in that book on the subject of the relations of colours to one another.)

The means Mr. Franks proposes for seeing these colours are probably as good as any that have been suggested; but it would have to be borne in mind that the incandescent electric light proposed as a standard might vary in colour according to the varying intensity of incandescence.

Yours truly,
T. W. BACKHOUSE.

Sunderland, 1887, May 11.

NOTES.

THE PHOTOGRAPHIC STUDY OF STELLAR SPECTRA.—Prof. E. C. Pickering has just published the first annual report of the investigations he has been carrying on at the Harvard College Observatory with the funds provided by Mrs. Draper. It will be remembered ('Observatory,' Vol. ix. p. 203) that the latter has provided for the prosecution of the photographic study of stellar spectra as a memorial to her late husband, Dr. Henry Draper, who during his lifetime accomplished so much in similar researches. The results already obtained have proved so important that Mrs. Draper has determined to have the work carried on in the most thorough manner possible, and that the attempt should be made to include all portions of the subject, so that the final results shall form a complete discussion of the constitution and conditions of the stars, as revealed by their spectra; and it is expected that the work accomplished at Harvard College may be supplemented and completed by the erection of an observatory in the southern hemisphere, where a similar method of study may be applied to the stars.

The investigations already undertaken comprise a catalogue of the spectra of all stars, down to south declination 24°, brighter than the sixth magnitude, a similar but more extended catalogue embracing all stars brighter than the eighth, and a detailed study of the brighter stars. Three telescopes have been used in the work so far, viz. an 8-inch Voigtländer photographic lens, the 11-inch photographic refractor with which Dr. Draper himself had been accustomed to work, and the 15-inch refractor of the Harvard College Observatory. The first two have been kept at work during the early part of every clear night for several months past; but Mrs. Draper now proposes to add two fine reflectors to the equipment of the observatory, one of 28 inches aperture and the other of 15, and to provide means for three telescopes to be kept continually engaged during the whole of every fine night. The spectra have been produced by returning to Fraunhofer's method, and placing a large prism in front of the object-glass. Four large prisms of 15°, the three largest with apertures of above 11 inches, have been formed by splitting a thick plate of glass diagonally, and have given excellent results. The spectrum formed in this way is exceedingly narrow, when the telescope follows the star accurately; but by giving a motion to it slightly differing from that of the Earth, the spectrum can be widened out into a band of any required breadth. The negatives thus obtained are enlarged afterwards by daylight, a cylindrical lens being placed close to the enlarging-lens, so as to remove the transverse lines in the spectrum which arise from various causes, such as irregular running in the clock, variations in the transparency of the air during exposure, and the like. The scale of enlargement employed widens the spectra out to a uniform breadth of four inches, whilst the length is increased five times. The sample given of part of the spectrum of Pollux is a most magnificent example of a stellar spectrum, being on a scale which would separate H and K by nine tenths of an inch, or about two thirds that employed by Ångström and Cornu in their maps. Nearly 150 lines are shown in a comparatively short section of the spectrum, with a clearness and definiteness that recalls some even of the best photographs of the solar spectrum. The ability to study stellar spectra on this scale opens out quite a new future for this department of astronomy.

On the same plate specimens are also given of spectra taken directly from the original negatives without enlargement. The size and character of the spectra used in the preparation of the catalogue of stellar spectra is illustrated by the spectra of ζ Ursæ Majoris and the adjacent fifth-magnitude star. An exposure of five minutes was given. One or two hundred such spectra are sometimes photographed on a single plate. The spectrum of Pollux from which the above-mentioned enlargement was made is shown and also one of Vega.

Amongst the points of interest which an inspection of the plates of the survey have brought out, it may be mentioned that a photograph of Mira Ceti shows G and *h*, together with four lines in the ultra-violet, as bright lines, the four latter corresponding to the well-known series of lines brought out in his photographs of Vega and other stars of the same type by Dr. Huggins. H and K are, however, dark in Mira, so that they would appear not to belong to the same series as the ultra-violet lines. Gore's new variable near χ' Orionis gives a similar spectrum to that of Mira. α Cygni shows H double, the two components differing in wave-length by about a tenth-metre.

The last part of the report gives the following information as to the progress of the various investigations which are to form part of the work. One series of plates for the catalogue of spectra of bright stars is already completed. The 8-inch telescope is used, each plate covering 10° square; and the exposure of equatoreal stars being five minutes, stars down to and including the sixth magnitude are embraced in this survey. 8313 spectra on 257 plates have been measured, and much of the reduction completed. 64 plates have been completed of the second cycle, and 2974 spectra measured. The results are to be given in a catalogue resembling the Harvard Photometry, which will contain the places of the stars for 1900, the character of their spectra as derived from each of the plates on which each is photographed, and their photographic brightness. The Catalogue of Faint Stars, for which the same instrument (but with exposures of an hour) is used, will embrace stars down to the eighth magnitude. 99 plates have been taken and 4442 spectra measured, so that in all 15,729 stellar spectra have been measured. The more detailed study of the spectra of the brighter stars is to be carried on by means of Dr. Draper's 11-inch photographic telescope, the 28-inch reflector being reserved for the study of the spectra of faint stars and also for the fainter portions near either end of the brighter stars. Variable stars and the stars showing banded spectra, bright lines, or other special peculiarities will be photographed with this instrument. The attempt will likewise be made to photograph the red portions of the spectra of the brighter stars. For the purpose of supplying the means of determining the wave-lengths of the lines, it is proposed to use some absorbing medium so as to give an absorption spectrum, the absence of a slit preventing the employment of the usual comparison spectra, and it is expected that finally displacements of the stellar lines due to a motion of recession or approach may be measured with the requisite accuracy.

Mrs. Draper has not only provided the means for keeping the powerful photographic equipment now in use at Harvard College in constant use, but also of reducing the results by a considerable body of computers, and of publishing them in a suitable form. There can be no doubt that the memorial she is thus erecting in memory of her late gifted husband will be every way worthy of his reputation and achievements; and one cannot but join in Prof. Pickering's wish that her example may be imitated hereafter in other departments of astronomy, and that other names may be commemorated by similar monuments of useful work accomplished.

THE MELBOURNE OBSERVATORY.—We have received Mr. Ellery's Report referring to the year ending June 30, 1886. From it we learn that the new transit-circle is in excellent order, the mounting exhibiting very satisfactory stability. There appears, however, to be a gradual lowering of the west pier, whilst other errors, with the exception of small periodic oscillations of the azimuth, have remained practically the same since the erection of the instrument. There also appears to be a decided diurnal change in the level, the east pivot being always slightly higher in the morning and lower in the evening. The observations with the transit-circle (3189 in R.A. and 1520 in N.P.D.) include observations of clock-stars, standard circumpolar stars, faint stars from the Melbourne zones, stars observed with comets, refraction stars, and stars observed at the request of the Bureau des Longitudes for insertion in the 'Connaissance des Temps.' The great telescope continues in good working order, but the mirrors are gradually absorbing more light, and will shortly, Mr. Ellery thinks, render repolishing absolutely necessary. With this instrument during the year 214 of Sir J. Herschel's nebulæ were finally revised, 7 were searched for and not found; 30 nebulæ were found which were not identified in the Catalogues, and may therefore be regarded as new. Extra-meridional observations of comets, measures of α Centauri, and a series of experiments and measures with Pritchard's wedge photometer, were made with the smaller equatoreals. The photoheliograph was not in working order for several months during the year under review, owing to difficulties incidental to the change of Sun-picture from 4 to 8 inches diameter. The number of solar photographs obtained during the year was only 92. No astronomical publications, except the joint Report on the telegraphic determination of Australian longitudes ('Observatory,' No. 123, page 199), were issued during the year. There is no reference in the Report before us to the very important work of the formation of the second Melbourne General Star Catalogue, containing the meridian results from 1871 to 1884 inclusive, mentioned in Mr. Ellery's last Report. We hope that it will be published without unnecessary delay.

PRIZES FOR COMETARY DISCOVERY.—Prof. Lewis Swift informs us that Mr. Warner has renewed his offer of prizes for cometary discovery. The following are the particulars:—

From April 1st, 1887, to April 1st, 1888, a prize of ($100) one hundred dollars is offered for each and every discovery of a new comet made between the above dates, subject to the three following conditions:—

1. It may be discovered either by the naked eye or telescope; but it must be unexpected, except as to the comet of 1815, which is now looked for.

2. (*a*) The discoverer, if residing in the United States or Canada, must send a *prepaid telegram immediately* to Dr. Lewis Swift, Director Warner Observatory, Rochester, N. Y., giving the time of discovery, the position and direction of motion with sufficient exactness, if possible, to enable at least one other observer to find it. (*b*) Discoverers in other countries must send *by immediate mail* a full account of the discovery, as above required, to Dr. Lewis Swift, as above.

3. In the United States and Canada this intelligence must *not be communicated to any other party or parties*, either by letter, telegraph, or otherwise, until publicly announced through the press by Dr. Swift, which he will do at once on information of the discovery.

Prizes will be awarded four (4) months after discovery and verification of claim.

Three disinterested scientists will be selected to settle any dispute that may arise regarding comet discoveries.

HISTORY OF ASTRONOMY DURING THE NINETEENTH CENTURY.—Little more than a year has elapsed since we had the pleasure of reviewing Miss Clerke's book, and the appearance of a second edition was somewhat of a surprise to us. The first opening of the book, however, at once reminded us of the rapid advance made during this short interval in at least one branch of our science. The frontispiece (a photograph of the Orion Nebula) and the vignette (photographs of Jupiter and Saturn) form eloquent testimony of the need for a new edition. The subjects of each chapter have been thoroughly revised and brought up to date; the few errors and omissions in the former edition have been carefully corrected, so that it would be a hard task to find any fault of importance. Part I. remains practically the same; it is Part II., "Recent Progress in Astronomy," which has naturally received most attention. Amongst other additions we notice that Chapter III. contains a short *résumé* of the Total Solar Eclipse of 1886, August 29, and Chapter XII. is enriched by a concise history of Nova Andromedæ; notices of the Uranometria Argentina and the Uranometria Nova Oxoniensis; while the space devoted to celestial photography is much increased, the discovery of the Maia Nebula and an account of Mr. Roberts's works forming a portion of the new matter. We are glad to see that Dembowski's work on double stars has received recognition. Perhaps the chief addition to Chapter XIII. is a description of "Gratings," unaccountably omitted in the first edition. An entirely new feature to the work is a chronological table extending from 1774 to 1887, *i.e.* from the first observation of Herschel to the publication of Lockyer's 'Chemistry of the Sun.' We think the Cordoba Catalogues might have found a place here. They surely form one of the most important, if not the most important, features of the years in which they respectively appeared.

THE FRAUNHOFER ANNIVERSARY, 1887.—We learn from

'Sirius' for May that on March 6 a large and influential company assembled in the Town Hall, Berlin, to do honour to the memory of Germany's great Physicist and Optician. Professor Helmholtz in his opening address briefly recounted the labours of Fraunhofer, and held him up as a fitting model to all young German mechanics. Herr Förster, Director of the Berlin Observatory, followed, saying that it was reserved for Fraunhofer to regain at one bound what Germany had lost since the time of Kepler; England, far ahead in mechanical arts, was, after the construction of the Dorpat telescope, obliged to strike sail, as even David Brewster acknowledged with pain. The Munich telescope became world renowned, and the degree of precision attained by Fraunhofer reacted on all mechanical and optical arts in Germany. The evening seems to have passed off pleasantly, and it was agreed that a "Fraunhofer Memorial Institution" should be founded.

MICROMETER MEASURES OF JUPITER AND SATURN.—From measures of these planets made at the Hongkong Observatory with the "Lee" Equatoreal during the years 1879–1886, and published in the "Observations and Researches made at the Hongkong Observatory, 1886," Dr. Doberck concludes that the equatoreal and polar diameters of Jupiter at mean distance are 38″·207 and 35″·942 respectively, and that the equatoreal semi-diameter at the mean distance of the Earth from the Sun is 99″·29. The measures of Saturn reduced to the planet's mean distance give the following results:—External diameter of ring 40″·28, diameter of Cassini's division 34″·42, internal diameter 26″·82, equatoreal diameter of Saturn 17″·22, and polar diameter 16″·53. The equatoreal semi-diameter at the mean distance of the Earth from the Sun is 82″·11.

ASTRONOMICAL PHOTOGRAPHY.—Prof. C. A. Young has published, in 'The New Princeton Review' for May 1887, a very opportune article bearing the above title. Starting with the statement that "it now looks as if the art of astronomical observation were likely, within a very short time, to undergo some such metamorphosis as occurred in connection with the invention of the telescope," Prof. Young goes on to give a brief history of the development of astronomical photography from the first attempts in 1840 down to the present time, a development to which his own countrymen contributed so largely. He then points out the various advantages and disadvantages attending respectively the employment of the reflector and of the refractor in photography, and with regard to the use of the latter draws attention to the Jena object-glasses *, produced under the superintendence of Prof. Abbe, as giving us reason to hope that the time may soon come when we

---

* [Prof. Young states that these lenses have been constructed only of sufficient size for microscope objectives. At the recent Conversazione of the Royal Society, however, Dr. Gill exhibited one of these object-glasses of 3 inches diameter, which under the severest tests shows no trace of colour. Dr. Gill also stated at the May meeting of the Royal Astronomical Society (see *ante* p. 215) that a perfectly successful object-glass of 6 inches diameter had been constructed at Jena.—ED.]

shall have new kinds of lenses, which will work together more satisfactorily than our present flint and crown, and thus remove some of the difficulties attending the employment of refractors in astronomical photography. Attention is also drawn to the researches of Prof. Vogel of Potsdam, who is understood to be engaged on the study of media which will be as sensitive to the yellow and green rays as the salts of silver are to the violet rays, and who, it is stated, can now obtain good photographs of star groups with an ordinary refractor. Dividing astronomical photographs into two classes—those in which the end is to produce a picture of the object, and those which are made for purposes of measurement—Prof. Young enumerates among those of the first class (with some details as to the progress which has been made in each) photographs of the solar surface, of the solar corona, and of solar prominences, photographs of the Moon, of planets, of comets, and of nebulæ. In the second class, as defined above, are noticed Eclipse photographs, Transit of Venus photographs, photographic star-charts, double stars, star groups and clusters, and stellar parallax, photography in meridian observations, photographic photometry, and the photography of stellar spectra. The article concludes with a well-merited eulogium on Prof. Pickering's recent achievements in the last-mentioned branch of astronomical photography.

A NEW Minor Planet of the 12th mag. (No. 266 if Luther's planet of April 11 be really Hesperia) was discovered by Herr Palisa at Vienna on May 17. Another, No. 267, was discovered by M. Charlois at Nice on May 27. It was of the 13th magnitude.

Elements and Ephemeris of Comet 1887 *e* (*Barnard, May* 12)*.

By Dr. H. OPPENHEIM.

THE orbit has been computed from an observation made at Cambridge, U.S., on May 12, and from two others made at Rome, May 15 and 17.

Elements.

T=1887 June 24·5559, Berlin M.T

$\pi -$ ☊	24° 21′ 30″	Mean Eq. 1887·0.
☊	244 54 32	
i	17 9 21	
log q	0·11510	

Ephemeris for Berlin Midnight.

1887.	R.A. h	m	s	Decl. °	′	Log Δ.	Log r.	Brightness.
June 1..	15	49	55	16	12·3 S.	9·5323	0·1299	2·0
5..	16	0	2	12	19·1	9·5185	0·1253	2·2
9..	16	10	46	8	17·1	9·5097	0·1216	2·3
13..	16	22	1	4	13·9	9·5062	0·1186	2·4
17..	16	33	39	0	17·5 S.	9·5081	0·1165	2·4
21..	16	45	31	3	23·8 N.	9·5149	0·1154	2·3

The brightness on May 12 is taken as unity.

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* Astron. Nachr. No. 2787.

No. 125.] JULY, 1887. [*Price* 1*s*.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Meeting of the Royal Astronomical Society on June 10 241

Articles:—

Sweeping for Red Stars and Stars with Remarkable Spectra. By the Rev. T. E. ESPIN, B.A., F.R.A.S. 258
Maxima and Minima of Variable Stars observed during the Year 1886. By JOSEPH BAXENDELL, F.R.S., F.R.A.S. 261
Maxima and Minima of Variable Stars observed during 1886. By JOSEPH BAXENDELL, Jun. 262
The Companion of Sirius. By Prof. C. A. YOUNG, Ph.D., For. Assoc. R.A.S. 263
Selenographical Notes. By THOS. GWYN ELGER, F.R.A.S. 263
Meteor Notes. By W. F. DENNING, F.R.A.S. 265
The Applications of Photography in Astronomy. By DAVID GILL, LL.D., F.R.S., &c. 267

Correspondence:—

The Colour of Achernar. By A. STANLEY WILLIAMS, F.R.A.S. 272
Jupiter and Lalande 25797. By JOHN TEBBUTT, F.R.A.S. 273
Lalande 18069. By JOHN TEBBUTT, F.R.A.S. 273
28 Andromedæ. By T. W. BACKHOUSE, F.R.A.S. 274
Proposed Nomenclature for Star-colours. By W. S. FRANKS, F.R.A.S. 275

Notes:—

Madras Meridian Circle Observations.—Royal Observatory, Greenwich.—The Eccentricities and Inclinations of the Asteroidal Orbits.—The Bamberg Observatory.—The Paris Observatory.—A New Minor Planet...276-280

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CONTENTS OF No. 124.

Page

Meeting of the Royal Astronomical Society on May 13 209
Meeting of the Liverpool Astronomical Society 224

Articles:—

Selenographical Notes. By T. G. Elger, F.R.A.S. 225
Meteor Notes. By W. F. Denning, F.R.A.S. 227

Correspondence:—

Motion of Jupiter's Red Spot. By W. F. Denning, F.R.A.S. 229
Comets and Asteroids. By W. H. S. Monck, M.A., F.R.A.S. 230
Examination of Stellar Photographs. By E. B. Knobel, F.R.A.S 231
L'Anneau de Saturne. By Dr. F. Terby 231
La Tache Rouge de Jupiter. By Dr. F. Terby 231
The Great Comet of 1825. By W. T. Lynn, B.A., F.R.A.S 232
First Discovery of the Great Nebula in Orion. By W. T. Lynn, B.A., F.R.A.S. 232
The Variable Star Lalande 10063. By J. G. Porter 233
Proposed Nomenclature for Star-colours. By T. W. Backhouse, F.R.A.S.... 234

Notes:—

The Photographic Study of Stellar Spectra.—The Melbourne Observatory.—Prizes for Cometary Discovery.—History of Astronomy during the Nineteenth Century.—The Fraunhofer Anniversary.—Micrometer Measures of Jupiter and Saturn.—Astronomical Photography.—Two New Minor Planets 234-240

Elements and Ephemeris of Comet 1887 *e* (Barnard, May 12). By Dr. H. Oppenheim 240

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THE OBSERVATORY,

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No. 125. JULY. 1887.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, June 10, 1887.

Dr. J. W. L. Glaisher, F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel and
Lieut.-Col. G. L. Tupman.

The Minutes of the preceding Meeting were read and confirmed.

Col. Tupman. We have received 66 presents since the last meeting, and amongst them is a 'Report of the present Condition and History of Astronomical Photography,' by Rayet of Paris, a volume containing the Madras Meridian observations of fixed stars for the years 1862-64; and from Harvard College we have received an interesting volume of observations by Mr. Chandler with the Almucantar. The observations are remarkable for exactness as well as for their originality.

Mr. Knobel. I might mention that the Almucantar is an instrument for taking the position of stars by their altitude. It does not determine their azimuth but their altitude, the circles of Almucantar being the old Arabic title for circles of equal altitude.

Col. Tupman. We have also received a paper by Loewy on a new method of determining the constant of refraction, and also the Annual Report of Admiral Mouchez, Director of the Paris Observatory.

Votes of thanks were passed to the donors of the presents.

Prof. Pritchard then described a paper on the Parallax of 61 Cygni as obtained by means of photography. He said: Inasmuch as the present communication professes to be nothing more than a preliminary and provisional announcement, perhaps the most interesting form of making it may be to give a short citation from the Report of the astronomical work done at the University Observatory at Oxford during the past year. It will be seen in the sequel that it is not without some importance to add that this Report was approved and adopted by the Lord Chancellor and other members of the Board of Visitors, including the Astronomer Royal. The following is the citation referred to:—"The somewhat hazardous enterprise of attempting for the first time in the history of astronomy to obtain the distance of fixed stars from our Earth by the aid of photography has been attended with success. The final results of the investigations have been placed in my hands only during the writing of the Report. The first observation was obtained on May 26th last year, and the last observation was effected on May 31st of the present year. The intermediate computations and reductions were systematically and regularly continued during the interval. They involved the reduction of no less than 30,000 bisections of star-images on 330 photographic plates procured on 89 nights . . . Simultaneously with these observations similar work has been in progress for the determination of the Parallax of μ Cassiopeiæ and Polaris. Photographic plates of the Pleiades have been also taken with a view of obtaining evidence of relative motion." Now comes the paragraph which is of much more importance than all the rest in one point of view because it pledges the University of Oxford for the first time to the continuation of the research. The paragraph is as follows (this is what I say and what they adopt):—"The funds granted by the University have been sufficient notwithstanding the continuous activity which requires a corresponding continuity of outlay. This grant, hitherto triennial—it is about £600 a year—expires on 31st December next. If the Board of Visitors see fit to request the University to continue the grant for five years instead of three it would enable me to commence a valuable and extended class of work which, under other circumstances, I should not be justified in attempting." This last sentence was altered by the Vice-Chancellor to this:—"They will propose to give the grant for five years instead of three in order that the Professor might undertake for the University—that is the word—a share in the production of the photographic map of the heavens, so that if Oxford should have anything to do with it it really and truly is not so much only the work of the Professor, but really upon that it becomes the University work." I merely add this, which I am bound to do for the gentlemen who have assisted me so well, that the details given above testify, without further words of mine, to the able assistance Mr. Plummer and Mr. Jenkins have given. Then follow a few numerical particulars on the remarks referred to in the foregoing citation; suffice it to say that the parallaxes of the two components of the double star 61 Cygni and the eight determinations all fall within the limits of probable error, and that probable error is only 13,000th of a second of arc. Also the results obtained with this marvellous agreement fall midway between the determination of Bessel and Dr. Ball.

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The errors which are due to non-symmetrical distortion of the film are those which must chiefly affect Prof. Pritchard's result, and such errors would be most likely to arise in the case of excessive contraction. Prof. Pritchard has rejected about 5 per cent. of the plates which he has measured on the ground of distortion, the *à priori* reasons for rejection being that the measures of the mutual distances of the comparison stars were considerably changed. I am informed by him that in nearly every case where the mutual distances of the comparison stars were so much affected by distortion of the film as to demand rejection, there was also a perceptible tear or fault in the film. I should have preferred that *à priori* some definite limit of discordance in the mutual distances of the comparison stars should have been adopted for the rejection of a particular plate, but I have no doubt that in the final and definitive discussion which has yet to be undertaken some such systematic system of selection will be adopted.

It will not always be possible to select comparison stars so symmetrically situated with respect to the star whose parallax is to be determined, as has been possible in the present case; and when this cannot be done, the secondary errors due to distortion of the film will have a much larger effect. For the complete elimination of the errors arising from symmetrical, as well as non-symmetical, distortion it will be necessary to have recourse to Dr. Loshe's method of latent lines, which has been adopted by the Paris conference, viz. to impress upon the sensitive plate the latent image of a *réseau* of lines (of known distances apart) previous to exposure of the plate to the sky, and after the plate has been exposed to the sky, to develop the picture of the stars and of the *réseau* seen together. Any contraction of the film in course of development will equally affect the picture of the stars and of the *réseau*, and the previously known dimensions of the *réseau* permit the absolute distortion of the film to be determined at any point.

Dr. Pritchard finds that the range of absolute distance amounts in the plates which have not been rejected to ±1″ even over the comparatively small distance of 1200″, and the fact that the correction for apparent scale-value is sometimes very different for the two diagonals proves that the *real* cause of the change in apparent scale-value is distortion of the film, and *not* change in the focal pointing. These results justify the Paris Congress in their decision that all the plates should have a *réseau* such as I have described, and I have no doubt that for the future in all photographic researches of precision such a *réseau* will be adopted. But the accuracy of these results of Dr. Pritchard has come to me as a genuine surprise. I say surprise because I was fully aware of the possible sources of error to which I have referred above. I ascribe the smallness of the residual errors (after correcting for scale-value) chiefly to the very symmetrical arrangement and small distances of the comparison stars, so that the greater part of the distortion of the film is eliminated by the corrections for change of scale-value. This correction was obtained by measuring the distance between the opposite comparison stars, and applying to each distance a corresponding correction proportional to the distance measured. But it is also found that the scale-value corrections so found are only applicable to a particular diagonal of the figure, and may have the opposite sign for the other diagonal. But the systematic errors which affect the final result I believe to be absolutely insignificant, for any of the errors that I can conceive will chiefly affect the accidental error of the result. Now as to the accuracy of the method and its comparative accuracy with the heliometer method.

Each of Prof. Pritchard's 89 equations depends upon four plates, that is on the mean of a very large number of measures of each of these plates, and the *mean error* of each equation is almost exactly one tenth of a second of arc. This accuracy corresponds as nearly as possible with the accuracy of one of my heliometer measures with my four-inch heliometer, so that, as matters stand, the photographic method is by far the more laborious and time-consuming of the two, for the same amount of accuracy. But Prof. Pritchard has devoted to this research an enormous amount of labour, which after being sure of the facts he has obtained, he certainly would not apply in future researches, and he would also adopt precautions which have been neglected in this confessedly preliminary research. Therefore I am not at present prepared to express an opinion as to whether, for similar accuracy, the heliometer or the photographic method will prove to be the more expeditious and convenient. The photographic method has the great advantage that you can employ all the stars on the plate as comparison stars; on the other hand, I do not see how the photographic method is to be successfully employed for the parallax of bright stars.

But of all the facts which have been brought out I think the most important at this juncture are the facts with regard to distortion or change of scale-value on the plate. They prove conclusively that simple plates taken without any *réseau* or other means of detecting distortion are, for refined *absolute* measurements, utterly useless. Prof. Pritchard has rather exaggerated than concealed the amount of these absolute errors in his statement that they range over two seconds of arc in the small distances measured in these researches of his. But his plates and distances are very small (2 inches and 2000″ respectively), and with much larger plates these deformations of the film would be still larger, and the necessity for a *réseau* still greater.

It is extremely important at the present time that we should have some results such as those of Prof. Pritchard before us. We have in these results a further proof of the admirable activity of the University Observatory at Oxford. There is no observatory in England which, proportional to its staff, has done more work, and no astronomer in England who has taken up with the same zeal a line of work entirely new, and which by most men of Prof. Pritchard's years would be neglected as modern or beyond their time. He has been the first to apply photography to the most refined and difficult problem of practical astronomy, and he has obtained a result which I firmly believe to be reliable, and which I believe also is capable of further improvement by fuller discussion. It is also a method which appears to have a great future importance, because it is capable of great refinement over this laborious and highly successful preliminary attempt. I am sure that the Society, along with myself, will congratulate Prof. Pritchard and his assistants most heartily.

Mr. Ranyard. On the occasion of the Soirée at the Royal Society, I was shown the photographs of Prof. Pritchard, and on the following day he wrote asking if I would take an early opportunity of stating what I had seen, and whether the photograph I saw did when magnified look like a heap of shingles, or whether the stars, as he described them, were uniform circular hard-edged disks with a fringe. I am happy to say that the granulation was smaller than I had supposed. Prof. Pritchard, at the time of reading his paper, stated that the photographs were under-exposed. Now, when a star first begins to impress its image on the plate, the granulation is very marked indeed; and I do not think I am wrong in saying that an under-exposed stellar image under a high power has an appearance very like a heap of shingle. But when the development goes on further, the shingle merges together very much. It is a question whether such images can be measured to the 1300th part of a second, or whether they can only be measured to about half a second or a quarter of a second, as I suggested the other evening. In fact, the different measures of this star made by very eminent astronomers do differ by nearly half a second.

Dr. Gill. Name the authorities.

Mr. Ranyard. Hall and Auwers.

Dr. Gill. What is the difference?

Mr. Ranyard. One is $0''\cdot56$, and one is $0''\cdot27$. The question is whether with these very great differences the observers are over-estimating their probable error. It is important that we should not under-estimate their probable errors, because the scale of the stellar universe depends upon it, and it is to my mind a very interesting question whether these eminent astronomers who have determined the parallax of these stars were right in their estimates of their probable error, or whether there is really a very much larger systematic error than they have themselves supposed. We cannot easily reconcile the different observations. Dr. Gill was quoting just now five or six of them with probable errors very much smaller than the difference between the determinations. Of course it is possible. The actual magnitude need not lie within the limits of the probable error, as I need not say to this meeting. It would be possible to have 3 or 4 determinations with a small probable error compared with the difference, and yet the probabilities are very greatly against such being the fact. What I would suggest is that there is really a very much greater systematic error in measuring these photographs than has been supposed. Now in each instance the spots that represent the stars are not absolutely circular even in the best photographs. The very tremor of the instrument is sufficient to cause distortion, and to make it difficult to determine the centre of the spot. In the photograph I was shown the larger star of 61 Cygni was quite 9 or 10 seconds across, and the question is whether its centre can be determined to 1000th part of its diameter or not. I think we shall only be able to judge of this when a number of independent observers have made a series of measurements, and it will be much more satisfactory to compare the measures made upon quite different principles by different observers than to compare one long series such as Prof. Pritchard has described. But I hope that we are on the point of making a very great advance by this photographic method.

Mr. Common. I would ask Mr. Ranyard one or two questions. Does he not think that the photographic image that Prof. Pritchard has taken of the star in question is a fairly sharply-defined circular dot, and is as much approximated to a circle as it is possible to be, rather than to a heap of shingles? I had the pleasure of seeing these photographs at the Royal Society the other night, and of meeting Mr. Ranyard there. Knowing his feeling on the heap-of-shingle question, I took him there and asked him to look at them through the micrometer. I rather expected to hear him to-night abandon the idea of the photographic image of a star being anything like a heap of shingles or like anything except a round circular spot, for it is easy to decide such a question by means of the micrometer.

Mr. Pritchard. I am in a difficulty to know how to begin dealing with objections of this nature. The remark that the Astronomer Royal made not very long ago about my friend Mr. Ranyard's observations was that he did not think Mr. Ranyard had any great experience in the matter of measuring distances. I emphasize most entirely the remark of the Astronomer Royal, for I do not know what any human being can be talking about when he compares the appearances of those three hundred bodies to heaps of shingle or anything approaching it. I have made 30,000 measurements, and is it likely that a man in his senses would really go on measuring 30,000 heaps of shingle? Could any man believe that? I believe Mr. Ranyard's remarks arise—I am speaking now very plainly—from want of experience. Then there is another little want of experience again in talking about probable error, the statement being that we have been reducing our probable errors. Why, good Heavens! The astronomer has got nothing to do with the probable error; it takes care of itself. He cannot control it. He cannot make it better or make it more. It is a matter of figures and a matter of arithmetic; and I cannot make my probable error smaller or greater. Dr. Gill was present while these computations were being finally worked up, and he knows perfectly well that it came out as I expected it to come out. It came out consistently with what I expected, simply because greater trouble had been taken with it. I say no more. There is the thing. There is honest work done, I hope and believe with intelligence. Begging Mr. Ranyard's pardon, I have no doubt that the result is comparable with the result of Bessel. I believe entirely in what Dr. Gill says that it is just equal, neither better nor worse. I do not wish to exaggerate. It is just equal to Dr. Gill's very best heliometrical determination, and that was all my object to find out what could be done. I have no more to add. I would not have said so much as I have, but for what Mr. Ranyard has said with, I may say, his limited experience. There are a number of gentlemen in this room who have not had experience of these sort of things, and they imagine that all this quantity of smoke must indicate some amount of fire. I make these remarks in order that those who have not had experience should not go on measuring 30,000 stars or 30,000 star-disks. They have something better to do I hope, and in order that your confidence should not be shaken in a new and, as I believe, most valuable method.

Mr. Bryant. I think there is one point to which photography might be applied with good results, namely, in the determination of the solar parallax. In 1892 we shall have another favourable opposition of the planet Mars, and if we can photograph the satellites at their greatest elongation when their apparent proper motions are comparatively small, and make measurements of these satellites with neighbouring stars, a good result may be obtained. The parallax of Mars in 1892 is, I think, about five-and-twenty seconds of arc, if not more. Consequently a much larger error could be tolerated than in the determination of the stellar parallax.

Rev. S. J. Perry. I think my friend Prof. Pritchard has been a little hard upon Mr. Ranyard; for if you look at a statement of Admiral Mouchez, who has had some experience as the head of the Observatory at Paris, you will find that he pictures these stars, under a very high magnifying-power, as something like a heap of shingle. Now Prof. Pritchard did not employ any high magnifying-power.

Prof. Pritchard. Oh! yes, I did.

Rev. S. J. Perry. Not such a high magnifying-power, I think, as Admiral Mouchez?

Prof. Pritchard. Oh! yes.

Rev. S. J. Perry. Well, we have a person who has had very great experience, and who describes certain stars as resembling, under high power, a heap of shingle.

Prof. Pritchard. Who is that?

Rev. S. J. Perry. Admiral Mouchez in his pamphlet, and therefore I say Mr. Ranyard only asserts the same as Admiral Mouchez, who may be identified with the MM. Henry, and does not speak as a person of no experience. I do not wish for a moment to detract from the great merit of the research of Prof. Pritchard; I think myself a magnificent work has been done; at the same time we can admire that without saying a single word against persons who bring forward their own views on the shape of stars under high magnifying-powers.

The Astronomer Royal. It is quite possible that the photographic image of a star may appear as a heap of shingle when you take it at some distance from the centre of the plate; but if you take stars near the centre of the plate and magnify them sufficiently to be able to measure their positions with the accuracy required for astronomical purposes (that is to say, representing a power of two or three hundred as applied to an ordinary telescope), I do not think it will be found that the disks represent heaps of shingle or anything approaching to it. I think they are perfectly measurable. I examined a plate of MM. Henry, and the extreme diameter of the disks of the smaller stars was about three seconds or a little less. The nucleus, so to speak, was about a second and a half, so but without any axis of symmetry, except an approach to one at an angle of about 90° with the axis. The polar extension is quite as great as the equatoreal. In 1883 there was a great northern rift, inclined at about 30° to the east of the Sun's axis. On each side of this are well-marked synclinal groups, one of them showing a remarkable double curvature, but there were neither rift nor synclinal groups in the south. In 1885 also there was a northern rift, but no southern one, and only one distinctly synclinal group.

Since the corona entirely surrounds the Sun, it is necessary to consider the effect of perspective upon its appearance. The synclinal groups, when they occur pretty symmetrically at opposite sides, indicate zones of this structure, while the short straighter rays in the polar rifts are probably the rays of these zones seen in perspective. Foreshortening may increase or diminish the apparent curvature of a ray, and greatly modify the appearance of the polar rifts. A very characteristic form of coronal ray is one which appears to start from the limb in a nearly radial direction, and is then abruptly curved and straightened; sometimes near its extremity it is slightly curved in a contrary direction, as was seen in 1871, 1883, and 1885. No one who has examined the photographs can resist the conclusion that the coronal rays in some way proceed from the Sun. The only distinction that the photographs show between an inner and outer corona is that the strongly curved and branching rays seem more numerous near the limb, otherwise the corona is of the same character throughout.

The only generalization with regard to the corona that had seemed at all supported by the evidence of the photographs was that the form of the corona had some connection with the solar activity as shown by the sun-spots. This was very well borne out in 1871, near a sun-spot maximum, and in 1878, at a minimum; but the photographs taken in 1883, 1885, and 1886 did not appear to confirm the theory.

The greatest care should always be taken in the orientation of the plates.

In order to get photographs showing the lower detail, it would almost be better to use wet plates, such as were employed in 1871; but the dry plates show a much greater extent of corona. Perhaps plates may be made in the future that will combine both these advantages. In the meantime, drawings would be useful, if observers would confine themselves to representing carefully the lower detail in some portion of the corona only, instead of attempting to draw the whole.

The President. There is probably scarcely any Fellow present who is not under an obligation to Mr. Wesley for services rendered, but I suppose it is only those who have served the office of Secretary in this Society who really know how great the services of Mr. Wesley are. But very many of us are aware how excellent an astronomer Mr. Wesley is, and how deep is his interest in the science entirely apart from his official connection with us, and I am delighted that Mr. Wesley has at last overcome his diffidence, and brought this paper before the Society and the astronomical world. I am also glad he has chosen this particular subject, which I know has been of very special interest to him for many years.

Mr. Grubb. Mr. President and gentlemen :—I have been communicated with by a considerable number of astronomical persons with regard to the possibility of transforming an object-glass of ordinary form into an object-glass suitable for photographic purposes; and although I do not see my way at present to recommend any solution of this difficulty so far as large fields are concerned, I have been making some experiments upon a form of object-glass which could be transformed from one glass into another. No doubt, by the use of a corrector of such a form as the Astronomer Royal has been using, very good results may be obtained for small fields. I do not see my way to use it for large fields. I do not see how it is possible to make it applicable for such purposes as a photograph of 2° square. During the course of correspondence on this matter, Prof. Stokes suggested to me a form of object-glass which it might be possible to transform from one to another without apparently any disadvantage; and I have made some experiments upon this, and, so far as they have gone, they have proved very satisfactory. It is very well known that by separating the lenses of the object-glass that the correction for colour is reduced, and by separating them sufficiently the correction can be reduced so far as is necessary for photographic work; but as is pointed out, I think, by Prof. Stokes and also by Dr. Gill, in separating these lenses the correction for spherical aberration is reduced at the same time as the correction for chromatic aberration, and consequently the definition of the image is injured. Prof. Stokes has pointed out that, if instead of object-glasses with the front faces so convex as they are at present, the front surfaces were made decidedly flatter and the back surface decidedly more convex, leaving the surface-power the same—if that form were given to the crown lens, the effect would be to reduce the correction of the spherical aberration. But supposing that the lens is made and the spherical aberration is found, as it is sure to be, slightly underrated, let it be corrected by figuring the lens. Now separate the two lenses and you reduce both corrections, and the spherical aberration becomes right and the lens is corrected for photography. I have tried this experimentally, and, so far as experiments go, it seems to succeed admirably. I do not propose to use this for a standard object-glass for photographic work; but amateur astronomers do not like to lay out a large sum of money on the purchase of an instrument which, though good for photographic work, may not be good for usual work.

The Astronomer Royal. One point that is very valuable about this principle is that the object-glass can be used with advantage for spectrum photography. The distance between the foci for F and H is so great with the ordinary object-glass that it cannot well be used for photographing the spectrum, while the form described by Mr. Grubb would be available for that purpose as well as for other applications of photography.

Dr. Gill. Another point I should like to ask Mr. Grubb is this—whether in this modified form the separation of the two lenses diminishes the available area of field?

Mr. Stone. If we could get a chemist to assist us in getting photographic plates that are sensitive to rays between D and E, we should be able then to use our ordinary object-glasses, and to focus better than we can now on the photographic plate; and I do not see why efforts should not be made in that direction.

Mr. Crossley. Perhaps some members of the Society may have attended the last soirée of the Royal Society, and seen some object-glasses exhibited by Prof. Pritchard which bear on this point, thus solving the problem without having to go to the great expense of changing the object-glass.

Mr. Grubb. In answer to Dr. Gill I may say, as the object-glasses have only been made a week, I am not able to say that they will be as good as any other, but so far as I can see they are quite as good.

The Astronomer Royal. I have been trying in a very limited way to effect what Mr. Grubb has been describing here—that is, to adapt an ordinary refractor to photographic work; but my object has been merely to adapt it to photography for the parts very near the centre of the field, and not to get an extensive field. The object of this photographic corrector which I bring before the Society is to provide at a very small expense a means of adapting any ordinary refractor to a certain class of photographic work. Suppose we take an ordinary object-glass. We have the rays B and E (roughly speaking) coming to a focus together, and F, G, and H coming to foci further and further out, so that when we are dealing with photographic plates we have the spectrum spread out longitudinally, as is well known, and, of course, at whatever point we take it, there will be much lateral chromatic aberration. That can be got over, as far as the rays near the centre of the plate are concerned, by inserting at some distance within the focus a correcting combination of lenses with reversed chromatic aberration, consisting of a convex flint lens and a concave crown lens in contact. I have arranged it (simply as a matter of convenience) that this corrector should act as a plate of glass for the F rays, and bring F and H together without altering the focus for F, whilst the focus for G falls a little within, so that, when the corrector is inserted, the focus will not be appreciably altered, and then the telescope could be used for taking photographs with the spectroscope, or for photographing double stars or any small object, such as a sun-spot or a crater in the Moon. There are several forms of this corrector that may be employed, but I have not thoroughly worked out the best form. I do not think really that the form makes very much difference. Of course the first condition is that the spherical aberration should be eliminated in the combination of the two lenses; and I have worked out three forms in which this condition would be satisfied, the internal surfaces being of the same curvature, so that they could be cemented together. There is, however, this point to which I wish to call attention, and that is, that if in the case of the 13-in. refractor at Greenwich the foci for F and H are brought together by the corrector, the focus for G falls nearly a quarter of an inch within, owing to irrationality of dispersion in the object-glass. Without the corrector the distance between F and H is $1\frac{3}{10}$ in. So that, although a very great improvement is made by this corrector, it must be borne in mind that in all photographs there is a great deal of outstanding chromatic aberration, and if the plates are sensitive for a large part of the spectrum this must take effect, especially in the case of brighter stars with long exposure. I think that is one of the causes why the images of bright stars with considerable exposure are so large, as outstanding chromatic aberration will account for that to a certain extent.

A Fellow. I should like to know where the corrector is placed.

The Astronomer Royal. I am afraid I omitted that point. It is placed about 30 inches within the focus, the focal length of the refractor being nearly 18 feet. That is, however, quite an arbitrary distance. The corrector might be placed much further in and then it would have to be larger, and at the same time the available field would also be larger. It is really a question of the balance of advantages and disadvantages, and you have to choose the best position, having regard to the particular work in view. If my object had been to get a large field, I should not have adopted this plan; but my idea was simply to provide an inexpensive means of uniting the rays for photographing objects of small dimensions. There is one point I do not think I alluded to—it is with regard to the question of field. Prof. Stokes called my attention pointedly to it. The difficulty of this corrector is that the axes of the pencils of different colours are dispersed radially as you go away from the centre of the field by the action of the corrector, as the refraction is eccentric, and this limits the field of sharp definition to a few minutes of arc. Thus, at a point out of the centre of the field the star's image is spread out laterally instead of longitudinally.

Mr. Gill. And that exaggerates?

The Astronomer Royal. It increases with the distance from the centre of the field; but within a distance of a minute and a half or two minutes it would not become sensible, I think.

Mr. Gill. The point I meant was, as you approach the focus to the corrector that exaggeration increased; but as you bring the corrector close to the object-glass you get more nearly to the conditions of a quadruple object-glass.

The Astronomer Royal. Yes, that is really the point—that by making the corrector larger and placing it nearer the object glass this dispersion of the axes diminishes. You gain in that way. I have brought here some trial photographs of Jupiter and double stars which were taken by Mr. Maunder with the corrector applied to our 13-in. refractor. Most of the photographs were taken with an enlarging doublet which magnified the primary image about seven and a half times, giving photographs on a large scale.

Col. Tupman. What form of magnifier did you use?

The Astronomer Royal. Dallmeyer's rapid rectilinear.

Mr. Common. It is the best for that purpose.

The President. I am glad to announce to the Fellows that Mr. H. C. Russell of Sydney is here, and that he proposes to show a pendulum he has brought with him.

Mr. Russell. It was my intention to have exhibited here the combination of pendulum that we use in Sydney for obtaining uniform circular motion for uniform driving-clocks. I have applied it to chronographs and the governing motion of the equatoreal. Unfortunately the ship has discharged all the instruments except the weights of the pendulum. It was no use bringing it here in a half-and-half condition. I have found it of great use to me for chronographic purposes. When once placed in position it does not require any subsequent adjustment, but the motion is always uniform. It is equally good for telescopic work; but it will be far better for Members to come and see it than for me to attempt to describe it, and I shall have very great pleasure in showing it. I have brought a few measurements of double stars which are intended to appear in the 'Monthly Notices.' If I might refer to one other matter, it is in regard to the very interesting subject the Astronomer Royal has brought before the meeting. For a long time past we have used at Sydney an enlarging combination very much in the form of the well-known objective; but I have found that by adjusting the distance between these lenses a perfectly flat field can be obtained, so that in photographing a series of squares which cover the whole field of view the lines may be made perfectly straight in photographing such objects as the Moon. It gives a focus equally good all over the field.

The President. The Society have already shown their appreciation of Mr. Russell's remarks. I will now call upon Mr. Buckney to say a few words about the Westminster clock.

Mr. Buckney. The accuracy of the Westminster clock is well known; but of course it has to be kept to Greenwich time as nearly as may be, and for that purpose the errors are corrected when they get beyond two seconds. During the period shown in this diagram the clock has not been corrected at all. The diagram represents the error every night for the period under review, viz. 72 days. Those errors have been taken from the Greenwich records, so that they may be taken as authentic. The errors, when they occur, are corrected by putting small weights on the pendulum, so as practically to lengthen it or shorten it as may be required. The pendulum is never stopped, but the escapement allows of the train being stopped, or, in fact, you may let it run on, but you cannot in that way make a smaller alteration than 4 seconds. For smaller quantities than that we use these little weights, which vary from a quarter of an ounce to about an ounce, and these little weights are added or taken away as necessity may require. The last alteration of the clock was made on March 29 or March 28, and since that time the clock has not been touched in any way. Except that it has been wound, no correction or alteration has been made. The diagram itself shows that the clock has gone with very small variations during the whole of that period. At one time it was 2 seconds slow from May 11 till 28. If you take the whole period from April 4 till June 7, the greatest variation during the whole of that time has been between one and two seconds.

Mr. Common. Can you give us the temperature?

Mr. Buckney. Not in the clock-room.

Mr. Common. That is an important thing, and might have some bearing on the regularity of the clock.

Mr. Buckney. There are various matters of that sort. In the first place, what makes the thing so very remarkable is that the hands of the dial weigh probably 2 tons; and this work is kept in intermediate motion by the clock, of course. It is a gravity escapement. Then there is another consideration, namely the course of the wind, which causes irregularities; and these depend on the direction of the wind. It sets the tower in motion.

Mr. Common. That is very important.

Mr. Buckney. When the wind is in such a direction as to be in the plane of the pendulum, that produces considerable errors. I have known in a heavy gale a variation of 8 seconds in a night, due entirely to that cause.

Mr. Common. Some explanation might be found for April 4, where there is a very sharp departure.

The Astronomer Royal. I think I ought to say with reference to this, that when you see a jump of a second it does not follow that the clock is accountable for it. This signal is only observed to the nearest second. It is just as a check on the going of the clock. It is not an astronomical observation that is made. In some cases it has been observed to half a second.

Col. Herschel. To what time of the day do they refer?

The Astronomer Royal. $11^h\ 38^m\ 0^s$ and $12^h\ 38^m\ 0^s$. There are two signals.

Col. Herschel. What are we to understand about the striking of the clock? Is it the first strike of the hour which indicates the time?

Mr. Buckney. Yes.

The President. I will now put it that we return our thanks to Mr. Buckney for his communication.

The following papers were also announced:—

Prof. G. W. Hough. "Observations of the Companion of Sirius made at the Dearborn Observatory, Chicago."

Prof. A. Auwers. "A Catalogue of 480 Stars to be used as Fundamental Stars for Observations of Zones between 20° and 80° South Declination."

J. E. Gore. "On the Orbit of Σ 1757."

T. G. Elger. "Physical Observations of Saturn in 1887."

H. C. Russell. "Measures of Southern Double Stars."

J. L. E. Dreyer. "A new general Catalogue of Nebulæ and Clusters of Stars, being the Catalogue of the late Sir F. J. W. Herschel, revised, corrected, and enlarged."

Capt. W. Noble. "An old Drawing of Jupiter."

J. G. Lohse. "Observations of Nova Cygni and some of the Planets made at Mr. Wigglesworth's Observatory with the 15·5-in. Cooke Equatoreal."

A. M. W. Downing. "A Comparison of the Star-places of the Argentine General Catalogue for 1875 with those of the Cape Catalogue for 1880, and with those of other Southern Star Catalogues."

W. H. M. Christie. "On a Corrector for adapting an ordinary Object-glass to Photography."

The following gentlemen were duly elected Fellows of the Society:—

Lieut. Arthur Mostyn Field, R.N., Herbert Ingall, Henry Addenbrook Wassell, Rev. Chas. J. Young; and Admiral Mouchez was elected a Foreign Associate.

The meeting adjourned at 10.0 P.M.

Sweeping for Red Stars and Stars with Remarkable Spectra.

PROBABLY there is no astronomical work so interesting as sweeping the heavens for a definite class of objects. The Rev. T. W. Webb was for years engaged in the work of sweeping for red stars and for fine pairs. On his decease I determined to continue his work amongst the red stars, and for some time made use of a beautiful 9-inch mirror which Mr. Calver placed at the disposal of the Liverpool Astronomical Society. With this instrument 32 stars were detected. It, however, was soon obvious that a larger aperture was necessary, and Mr. Calver furnished me with an equatoreal

tor of 17¼ inches aperture. The work was begun with this
ptember 1885, and has been continued up to the present date.
ovember 1886, after various experiments, a spectroscope was
ed capable of showing spectra of stars down to the 9th mag.
he D.M. scale. The original plan of research was thus ex-
d, and since then each new red star has been examined with
pectroscope. Up to the present date over 220 new red stars
been detected; amongst these are 87 stars with fine banded
ra of the third type and 23 stars of the fourth type. The
r class, from their extreme rarity, form a most interesting line
search alone. The total number at present known, including
found with the 17¼, is only 84, and in all probability few
of this class above the 8th mag. remain undetected in the
ern heavens. The following table shows the magnitudes of
at present known :—

Magnitude.	Known stars.	New, found with 17¼.	Total.
5·0–6·0	4	0	4
6·0–7·0	14	0	14
7·0–8·0	17	3	20
8·0–9·0	12	16	28
Below 9·0	6	4	10
Variable........	8	0	8

nér ('Sur les étoiles à spectres de la troisième classe') finds
hese objects preponderate greatly in the Milky Way. The
tars found with the 17¼ are also all at no great distance from
ilky Way. Many hours' sweeping has been devoted to parts
heavens most distant from the Milky Way, but no new
pe star has been found, although many new III.-type stars
detected. On the nights becoming too bright for further
omical work, the whole of the stars of types III. and IV.
by Dunér, together with the new ones, were charted, both to
any peculiarities in grouping and to define at a glance the
of the heavens that still remain to be swept. Dunér points
at the IV.-type stars have a tendency to collect in groups,
nds two places in the heavens especially marked. These he
at R.A. 305°, Decl. +40°, and R.A. 85° +25°. The sweeps
he 17¼ have fully borne this out, adding four new ones in
st and eight in the second. The centre of the second region,
er, seems to be further north by some five degrees. It is
ly the finer region, though the stars are smaller. The fol-
seem to be the principal centres of grouping in the order
ccur in following the galaxy northwards :—

R.A.	Decl.	No. of stars.
105°	+ 0°	7
85	+30	14
52	+60	7
305	+36	14

It will be obvious from this that the winter galaxy is much richer than the summer one. Indeed, if the galaxy is divided into two parts, from R.A. 8°, Decl. +64°, to R.A. 113°, Decl. −20°, which we call A, and from R.A. 8°, Decl. +64°, to R.A. 263° −20°, which we will call B, we shall find that:—

A has 39 stars, B has 28 stars.

Among the variable stars only eight have spectra of the IV. type. Four of these, viz. S Aurgæ, 26 Pickering, U Cygni, V Cygni, lie in or near the Milky Way.

The III.-type stars are much more numerous, and do not seem to show the same tendency to collect in the Milky Way. The colour of these stars is represented by every shade from very red to yellow, whereas the IV.-type stars are all very red or red. The total number projected on the chart is 384—297 given by Dunér, and 87 found independently. It is difficult to sweep any part of the heavens without finding some. It is remarkable that they seem more numerous to the north of the galaxy than to the south of it. From a rough estimation, about 63 per cent. lie to the north. The following seem to be the chief centres of grouping:—

R.A.		R.A.	
85°	+40°	215°	+30°
100	+ 0	248	+40
107	+50	283	+40
195	+ 0	309	+17

The one at 283° +40° is the most remarkable. The whole of Lyra and the N. part of Cygnus seem to abound in stars of type III. The part of the heavens from 0ʰ to IV., and from Decl. −20° to Decl. +90°, is singularly poor in III.-type stars. There are only 36 stars at present discovered in this large extent of sky. Another curious gap occurs in the region N. of Lyræ, and having a centre at R.A. 270°, Decl. +60°.

Almost all the long-period variable stars belong to type III.: in fact, taking Dunér's numbers and adding to them the new stars, 12 per cent. of the III.-type stars are variable. For the IV. type the percentage is nine.

The new variable stars discovered with the 17¼ are:—

(1)	+47°, No. 194,	0ʰ	39ᵐ	+47°	37′·6,	var. 8ᵐ·5±	−14ᵐ·0±	P. ?
(2)	+ 8 , No. 3780,	XVIII	32	+ 8	43 ·5,	var. 6 ·5	−10 ·0±	P. 310ᵈ±
(3)	New star	XIX	58	+49	43 ·0,	var. 7 ·0	− ?	P. ?

Two maxima have been obtained of No. 2. Mr. Baxendell watched No. 1 till it disappeared in his instrument, and probably its minimum will be difficult to reach with 17¼. No. 3 has sunk below 10·0 mag.

T. E. Espin.

Wolsingham, Darlington.

Maxima and Minima of Variable Stars observed during the Year 1886.

ꝛ observations from which the following results are derived ꝛre made with the telescope employed in previous years (an uatoreally mounted achromatic of 6 inches aperture), a power of being generally used, and occasionally one of 125.

Star.	Max. or Min.	Observed Time.	Mag.
U Cephei ……	*m.*	Feb. 26, $9^h\ 24^m$	9·2
R Arietis ……	M.	Feb. 6	7·8
	m.	Nov. 27	13·0
T Tauri ………	*m.*	Feb. 16	12·8
Nova Orionis ….	M.	Dec. 9	
V Geminorum ..	M.	Feb. 20	8·5
	M.	Nov. 17 ± 3 days	8·7
U Geminorum ..	M.	March 9·3	9·4
	M.	Dec. 1 +	9·3
R Boötis ………	*m.*	April 26	12·3
U Boötis ………	*m.*	March 17	13·5
S Coronæ………	M.	April 28	7·2
T Herculis ……	*m.*	Dec. 6	13·0
R Cygni . ……	M.	March 22	6·7
S Vulpeculæ ….	M.	Oct. 23	8·9
	m.	Dec. 15	9·7
χ Cygni ………	M.	Jan. 16	4·6
T Aquilæ ……	M.	May 29	9·1
	M.	Oct. 5	9·2
	m.	Dec. 1	10·8
R Sagitta ……	M. *s.*	May 29	8·8
	m. p.	Nov. 10	9·85
	M. *p.*	Nov. 27	8·6
	m. s.	Dec. 14	9·0
U Cygni ………	*m.*	Jan. 9	10·6
	M.	Aug. 14 ± 4 days	7·8
V Cygni ………	*m.*	Aug. 25	13·3
R Delphini ……	*m.*	Dec. 12	11·6
S Delphini ……	M.	July 1	8·2

Notes.

Geminorum.—When at 13·5 mag., on the rise to the March mum, U was well defined and ruddy; but at maximum it not well defined, and its colour was a dull white. At the mum in December the star was again ill-defined, and its colour ll white.

Boötis.—The rise to maximum was followed to June 30, when mag. was 8·7, which is the highest yet observed. Unfortuy the observations were then interrupted by illness.

R Cygni.—At minimum this variable was invisible and below 13·7 mag.

T Aquilæ.—After the remarkable shortening of the period of this variable (referred to in my paper in the 'Observatory' for March 1886, p. 122), it now appears to be increasing and rapidly approaching its former value. This star is Schönfeld's S Aquilæ.

R Sagittæ.—The letters *p.* and *s.* in the second column signify principal and secondary. At the calculated time of maximum in September observations were secured on two nights only, the 14th and 17th, when the mag. was 8·75.

U Cygni.—It is noteworthy that the mag. at minimum of this variable, which gradually fell from 9·4 in 1870 (when its variability was discovered by Mr. Knott) to 11·6 in 1880 to 1882, has since gradually increased to 10·6. It is, however, remarkable that the mag. at maximum has remained practically unchanged.

V Cygni.—The mean period of this variable from two observed maxima and two minima is 444 days.

R Delphini.—This is Schönfeld's S Delphini.

S Delphini.—This is Schönfeld's T Delphini.

The Observatory, Birkdale,
Southport, 1887, June 2.

JOSEPH BAXENDELL.

Maxima and Minima of Variable Stars observed during 1886.

UNFORTUNATELY, owing to severe illness and exceptionally unfavourable weather, my observations of variable stars during 1886 suffered considerable interruption. I, however, succeeded in obtaining the following dates of maxima and minima, and, with the exception of Nos. 2 and 4, the light-curves from which they have been derived appear to me to be fairly satisfactory. The observations were all made with the 6-in. achromatic of this observatory, and I have invariably used a power of 80.

Star.	Max. or Min.	Observed Time.	Mag.
U Cephei........	*m.*	Feb. 26^d 9^h 24^m G.M.T.	9·3
S Cassiopeiæ	M.	July 22 ±	7·9
U Geminorum ..	M.	March 9·0	9·45
	M.	Dec. 1 ±	9·4
R Ursæ Maj.	M.	May 1	7·5
	m.	Nov. 20	13·6
T Ursæ Maj.	M.	March 1	6·4
	M.	Nov. 17	6·8
S Ursæ Maj.	*m.*	April 17	13·1
	m.	Dec. 8	12·9
S Boötis	M.	May 12	8·2

Notes.

S Cassiopeiæ.—During the rise to maximum a pause of 43 days occurred, the magnitude at the time being about 12. Afterwards the rise was remarkably rapid.

T Ursæ Maj.—The latter portion of the rise to the first of these maxima was very rapid, and the magnitudes at both maxima were exceptionally high. Joseph Baxendell, Jun.

The Observatory, Birkdale,
Southport, 1887, June 2.

The Companion of Sirius.

(Measures made with the 23-inch Equatoreal of the Halsted Observatory, Princeton, N. Jersey.)

The following measures of this object are all that we have been able to obtain during the past season. It has become very difficult to deal with except when the atmospheric conditions are unusually favourable, then it is still easy enough On six out of the ten nights on which we tried to observe it, the companion could not be so much as glimpsed during half an hour or more of careful watching. On one night (Feb. 4) it was visible intermittently, and on the remaining three was fairly seen.

The position-angles were measured with the eye perpendicular to the line joining the stars, and are each the result of from five to seven independent settings; the distances are each deduced from four readings of the screw, except on Feb. 4, when only two readings were made.

Date, 1887.	Position.	Distance.	Hour-angle.	Power.
	°	″	m	
Jan. 27	24·6	6·91	20 east.	460
Feb. 4	26·0	7·13	1 "	370
Feb. 12	25·1	7·15	40 "	460
April 7	25·9	7·13	2 west.	460
1887·139.	40	7·08	Mean.	...

1887, May 16. C. A. Young.

Selenographical Notes.

Dark Spots near Hyginus.—In the current number of 'Sirius' Dr. Klein revives interest in the region surrounding Hyginus by drawing attention to certain dusky markings visible in this neighbourhood under suitable conditions of illumination. These and other similar features have for many years past received more or less attention from observers, with a view to determine, if possible, what they really represent; but, with a few exceptions, the observations have been conducted in such a desultory and unmethodical fashion that they have led to no very definite result. Among living selenographers no one has displayed more zeal in this branch of lunar research than Dr. Klein, of Cologne, who long ago pointed out that evidence of change is more likely to be furnished by the careful and systematic study of objects of this character than of larger and more conspicuous formations, where, unless changes of vast magnitude occurred, it would be less easy to detect alterations than in the case of minute though definite features, which can be drawn, mapped, and described without ambiguity. The hilly district between Boscovich, Agrippa, and Hyginus is well known as a locality in which certain curious dark markings abound; and when, some eight years back, Hyginus N was a centre of attraction, many of them were recorded, though not with any approach to accuracy.

In published charts of this region these features are in no instance satisfactorily shown. Mädler, in his special map of the neighbourhood of Agrippa and Triesnecker, shows a dark oval area a little north-west of Hyginus *a*, and a second, extending from the northern end of the first nearly up to Hyginus. He also draws a large elliptical dark spot some little distance west of Hyginus C, and an irregularly shaped dark marking bordering the southern flank of the great rill south-west of the same crater. Schmidt shows the latter and another dusky area, with a white spot upon it, south-west of Hyginus, forming the apex of an equilateral triangle, with a line joining Hyginus and *a* for the base. It is well known that neither Mädler nor Schmidt professed to pay special attention to features of this description, and their records can only be regarded as proofs of the existence, and not as reliable representations either of the form or positions, of the markings. If it were otherwise, there would be some ground for concluding that changes of considerable magnitude have taken place since the epoch of Mädler's drawing in all the dark spots he delineated, for in no instance do they agree as regards position with those so carefully set down in Dr. Klein's little maps. Bordering Hyginus on the south, a dusky area extends for a considerable distance in an easterly and south-westerly direction. On January 23, 1885, when the morning terminator lay west of Archimedes, a row of three minute spots was noted on its surface, and a light streak directed from the crater towards Hyginus *a*. Under a higher sun, viz. about two days before full Moon, the patch could no longer be traced so far south as before, but was still prominent immediately round the rim of Hyginus, where it exhibited a very irregular outline. The row of three craterlets was again seen, with the addition of two similar objects on the west, a faint indication of dusky shading being traceable all round them. At the foot of the hilly land on the N.E. of Agrippa and a few miles south of the western arm of the great Hyginus cleft. Dr. Klein has observed some very interesting and suggestive features which, like the marking fringing Hyginus, seem to undergo considerable modifications under varying angles of illumination. Under a low sun a large dusky area is visible here, which, as the solar altitude increases, is subject to a notable change. Under a high light two circular dark spots occupy the site—one, the more northerly, being the darker, and having two minute white spots [illegible] nearly central, and the other resembling an ill-defined dusky ring, with a darker interior and a central bright spot.

Without a reference to Dr. Klein's diagrams it is difficult to describe the position of the other areas he mentions; the reader must consequently be directed to the article itself, in which he urges the importance of undertaking a rigid and systematic examination of these, at present, mysterious objects under every possible phase of illumination, so that an [illegible] record may be prepared, which may be appealed to with confidence by future observers.

Thomas Gwyn Elger.

Kempston, Beds, 1887, June 23.

Meteor Notes.

Very fine weather enabled observations to be secured here on the nights of June 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, and 25, and 169 shooting-stars were seen in 35 hours of work. The best nights were the 17th, when 20 meteors were seen in 3[illegible] hours, and the 21st, when 24 were seen in 3 hours; but taking the whole period they were somewhat scarce, the horary number being only about 5.

The positions of the chief radiants derived from these observations are as follows:—

No.	°	°	Notes and Comparisons
1....	268	−24	Meteors slow and bright. New shower.
2....	270	+47	Slow and bright. Here 27[illegible]° +4[illegible]°, June 14 [illegible] July 25.
3....	274	+69	Swift and short. In Draco near ψ.
4....	280	+43	Swift and short. α Lyrids. Max. June 2[illegible].
5....	285	+23	Rather swift. Sawyer 287° +25°, June 24 [illegible] July 3.
6....	291	+52	Swift and short. Near χ Cygni.
7....	302	+24	Swift. Seen also in 1885 at same period.
8....	335	+57	Very swift. At [illegible] Cephei. [illegible] has a radiant at 33[illegible]° +57°, June 14.

Many other showers of more feeble character were displayed, but the α Cepheids (312° +60°), usually one of the brightest of June displays and well seen here in 1885 and 1886, have not reappeared this year. In the mornings I saw several fine meteors with streaks from radiants in Cassiopeia, Andromeda (6° +35°), Perseus and Pisces (345° ±0°). The brightest meteor registered here between June 10 and 25 was on the 14th at $13^h 5^m$. It was nearly equal to Venus and flashed out very suddenly just above γ Cephei, leaving a streak for about 5 secs. from 349° +68° to 300° +87½°; radiant probably at 353° +38°.

On June 12 at $10^h 14^m$ another large meteor was seen by several persons at Bristol. From their descriptions the disappearance must have occurred in N. 7° W. at altitude 10°. The same object was observed at Manchester by Mr. G. B. Hallowes, who gives the approximate path as from 187½° +33° to 147½° +35° and estimates the magnitude as equal to Venus. Colour yellow, motion moderately swift, about 4 or 5 seconds. These observations indicate the height of the meteor at end point to have been about 27 miles over a point off Southport on the Lancashire coast. The radiant-point was somewhere near Arcturus, but the exact place is uncertain, the records being discordant as to direction.

A large detonating fireball was seen in the south of Australia on the afternoon of March 19 last, soon after 4 P.M. It left a smoke trail for half an hour, and at Warnambool, Terang, Merino, and Coleraine a report like distant thunder followed its explosion. An observer writing from Coleraine says:—"A brilliant ball of fire shot from the zenith in a clear sky to 30° above the horizon and then disappeared, as it exploded leaving a large cloud of white smoke which was visible for half an hour. Exactly six minutes afterwards two distinct shocks like cannon reports were heard with a perceptible tremor of the atmosphere." Mr. R. B. Smyth, dating from Sandhurst, says the silvery train of the meteor was noticed at an alt. of 30° in the S. heavens. The fireball must have been distant about 75 miles, in an easterly direction, from Coleraine, for sound would traverse this space in six minutes as noted by the observer there, but the path of the meteor cannot be definitely found, the descriptions failing in necessary details.

In the 'Observatory,' Vol. iii. p. 414, I mentioned a brilliant meteor observed at Greenwich in 1880, April 4, at $10^h 7^m$, with path from 63° +38° to 74° +41°, and at Bristol from 293° +69° to 246° +53°. The meteor left a thick train and moved slowly. It is curious the radiant of this body was below the horizon at the time of its appearance. On comparing the two observations it is found that the meteor was first seen at Greenwich when 47 miles above a point of the Earth's surface between Kidderminster and Stourbridge, and travelling in the direction to W. 47° N., it ended closely N.E. of Chipping Norton when 54 miles high. The meteor had therefore *ascended* some 7 miles during its real path of 49 miles. Apparent radiant-point at 31° +19° near α Arietis. At Greenwich the path observed was 32 miles and the duration 2 secs., so that the velocity was about 16 miles per second. A similarly slow meteor was seen by Mr. Dunkin at Blackheath, by Mr. Coates at

Moulton Spalding and by another observer at Oxford in 1880, April 7, at 8^h 17^m ('Observatory,' iii. pp. 414 and 536). This belonged to a radiant at 38° +18° and its origin is doubtless to be referred to the same stream as that of the small bolide of April 4 previously described. The apparent centre of divergence of this pair of doubly observed meteors was at about 34° +18°, but the zenithal attraction would require a correction of several degrees to the observed place, so that the radiant would be really about 30° +11°. Meteors from positions below the horizon are somewhat rare, though I have occasionally seen them. In 1879, Nov. 12, 10^h 17^m, I noticed a bright Leonid with a path of 98°, though the radiant had not then risen. This meteor was also seen by Mr. Corder at Chelmsford, and Mr. Grey at Bedford. On Oct. 20 of the same year, at 8^h 32^m I registered a 1st mag. Orionid moving slowly from 86½° +22° to 79° +29½° and leaving a remarkably bright streak. The radiant was slightly below the horizon.

In the recently published 'Beobachtungen Angestellt am astrophysikalischen Observatorium in O'Gyalla' (Ungarn, 1885), by Dr. Nicolaus v. Konkoly, are given the paths of 647 meteors observed in that year, together with a list of 71 radiant-points deduced by Dr. v. Kövesligethy. These radiants include many positions for the Perseids, Cassiopeids, and other well-known displays of the August epoch. The best average positions derived from Dr. Kövesligethy's list are:—

Average radiant.	No. of Meteors.	Positions averaged.	Epoch 1885.	Notes.
° °				
5 +65	29	3	August 8–12	These showers in the region of Cassiopeia and Andromeda are unquestionably distinct, reappearing every year with the Perseids.
13 +52	47	6	August 8–12	
24 +59	12	3	July 27, Aug. 9	
25 +44	12	2	August 3–9	
30 +28	13	2	August 10–12	Shower in Triangulum.
47 +58	104	17	August 6–12	Perseids. Max. Aug. 10.
69 +51	13	2	August 10–12	Weiss, 70° +53°, Aug. 13, 1869.
154 +61½	15	3	August 10–12	Shower near α–β Ursæ Maj.
312 +47	16	3	August 3–9	Greg's Cygnids I. at 309° +48°.

Dr. Konkoly's volume also contains the positions of 15 stationary meteors.

W. F. Denning.

The Applications of Photography in Astronomy[*].

Little more than a year ago Mr. Ainslie Common delivered a lecture in this place on the subject of "Photography as an aid to Astronomy." Given by one who is a consummate master of the art of celestial photography, that lecture (complete as to history and full of suggestion as it was) would, under ordinary circumstances, have precluded further reference to the subject in these Friday evening lectures for some years to come.

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[*] Lecture delivered by David Gill, LL.D., F.R.S., Her Majesty's Astronomer at the Cape of Good Hope, on Friday, June 3, 1887, before the Royal Institution of Great Britain. By kind permission of the Lecturer.

But the past year has witnessed such developments of the subject, and the importance of photography in astronomy has been so much advanced by the conclusions of the recent Astro-photographic Congress, as to afford a reasonable apology for the present lecture.

On the 16th of April last there was held at Paris a Congress attended by upwards of fifty astronomers and physicists, representing nearly every civilized nation in the world. It was convened for the purpose of considering a scheme of international co-operation in the work of charting the sky on a large scale. Or, rather, its object was to obtain a series of pictures, which, taken within a comparatively limited period of time, and with the necessary precautions, would enable astronomers of the present day to hand down to future generations a complete record of the positions and magnitudes of all the stars in the heavens to a given order of magnitude. The labours of that Conference are now concluded, certain important resolutions have been adopted, and the way has been so far cleared for giving these resolutions practical effect.

It seems of importance therefore to lay before the members of the Royal Institution some account of the history of this remarkable Congress, to illustrate and explain the grounds of the conclusions which it has arrived at, and otherwise to bring the history of photographic astronomy up to the present date. I pass over the already well-told early history of celestial photography, except in so far as it relates to star-charting. It was Warren de la Rue who first called attention to the means furnished by photography for charting groups of stars. In his Report to the British Association at Manchester in 1861 on the progress of celestial photography, he indicates a photographic object-glass of short focus as the instrument best suited for the purpose, and he states that by mounting such a lens and camera on an equatoreal stand provided with clockwork he has photographed such groups of stars as the Pleiades, the chief difficulty being not to fix the images of the stars, but to distinguish them from the specks which are found on the plates or rather in the collodion.

In 1864, Rutherfurd of New York completed a telescope of 11½ inches aperture and 14 feet focal length, specially constructed for celestial photography, and obtained fine photographs of stars to the 9th order of magnitude. His remarks, although quoted in Mr. Common's lecture last year, have such importance on the present subject that I venture to repeat them.

"The power to obtain images of the 9th magnitude stars with so moderate an aperture promises to develop and increase the application of photography to the mapping of the sidereal heavens and in some manner to realize the hopes which have so long been deferred and disappointed.

"It would not be difficult to arrange a camera-box, capable of exposing a surface sufficient to obtain a map of two degrees square, and with instruments of large aperture we may hope to reach much smaller stars than I have yet taken. There is also every probability that the chemistry of photography will be very much improved and more sensitive methods devised."

Mr. Common well remarks that in the light of recent work these words are almost prophetic.

But Rutherfurd did not stop here. In the eye of an astronomer a picture of stars is of comparatively little importance unless it is capable of accurate measurement. Recognizing this important feature of the case, Rutherfurd devised a suitable apparatus, which he applied to the measurement of two of his photographs of the Pleiades. These measures having been put into the hands of Dr. Gould, that astronomer compared them with those of the same group of stars made by Bessel with his celebrated heliometer, and found a satisfactory accordance *.

Encouraged by these results, Dr. Gould, when he went to the Argentine Republic in 1870 to found the Cordoba Observatory, which has since been rendered so famous by his labours, took Rutherfurd's telescope with him. Unfortunately one of the lenses was broken in transport, and such delay was incurred in replacing it, that the proposed work could not be begun till 1875. But thanks to the clear skies of Cordoba, and the marvellous activity of the observatory under Dr. Gould's direction, 1350 photographs were obtained in the course of a few years, containing representations of all the principal star-clusters of the southern hemisphere, besides a special series of plates taken for the purpose of determining the parallax (or distance) of several of the more remarkable stars in the southern hemisphere.

This fine series of pictures is now being submitted to measurement by Dr. Gould, and the results are awaited with the greatest interest by all astronomers.

The first of Dr. Gould's plates were taken with the old wet collodion process, but the work was afterwards greatly facilitated by employment of the more sensitive modern dry plates.

It was, in fact, the introduction of the gelatine dry-plate process in 1876 which really paved the way for the rapid development of celestial photography. The convenience of the manipulation and the greater increase of sensitiveness of the plates at once placed a new power in the hands of astronomers. Draper photographed the nebula of Orion in 1880; and after trials, commencing in 1879, Common succeeded in obtaining the exquisite photographs of that object which have been exhibited more than once in this theatre.

In 1882 appeared the splendid comet of that year. At the Royal Observatory, Cape of Good Hope, we were not at the time engaged in photographic operations. Several photographers in

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* Astron. Nach. No. 162, vol. xlviii. Dec. 1866.

the Cape Colony found it possible to obtain impressions of the comet, but they were unable to secure pictures of scientific value, because they were unprovided with means to follow the diurnal motion. I had no available camera belonging to the observatory, and no experience in the development of modern dry plates. In these circumstances I applied to Mr. Allis, a skilful photographer in my neighbourhood, who eagerly consented to co-operate with me in the work. I arranged means to attach his camera to the stand of an equatoreal telescope, and the telescope itself was employed to follow the nucleus of the comet accurately during the whole time of exposure by the aid of the driving-clock and with small corrections given by hand. The lens employed had an aperture of only 2 inches, and a focal length of 11 inches; but the result was a series of pictures, one of which, obtained after an exposure of two hours, is now on the screen.

The photograph shows a very satisfactory delineation of the tail and envelope of the comet.

Important and useful as these results were, there was another feature of the pictures which seemed to me still more so. In forwarding copies of these photographs to the Royal Astronomical Society of London and to the Paris Academy of Sciences, I drew particular attention to the large number of stars shown upon the plate, and insisted upon the importance of the means thus offered to photograph comparatively large areas of the sky and thus rapidly make charts of the entire heavens.

The one step wanting was now provided, and the new and more sensitive dry plate rendered the former suggestions of De la Rue and Rutherfurd now valuable and practicable.

Formerly the old collodion wet plates required large instruments (with small field) and long exposure to depict stars even to the 9th magnitude, and astronomers trusted entirely to the accuracy of their driving-clocks, which could not follow a star with perfect accuracy during a long exposure. Now the modern rapid dry plates in conjunction with the large fields of the photographic objective overcame the first of these difficulties, and the plan of employing a guiding telescope overcame the second.

The use of a guiding telescope was not even a new device, for it had been employed long before by Hartnup and others, who, in their early attempts to photograph the Moon, kept the image of a lunar spot by hand upon the cross wires of the finder of the telescope during the long exposures then necessary.

There was thus nothing really new either in my suggestion or in the *modus operandi*, only the result was a fortunate one, for Mr. Common says that "these photographs came to him as a revelation of the power of photography for the purpose of star-charting"[*], and Admiral Mouchez tells me that these Cape photographs and my suggestions first directed his attention and that of the brothers Henry to the application of photography to the work of star-charting, which had for many years been carried on at Paris by the older methods of astronomy.

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[*] 'Proc. Royal Institution,' vol. xii. part iii. p. 734.

Common was amongst the first to take up the work in England, and here on the screen is one of his photographs with a 4-inch lens executed in 1883. But being engaged in other researches, Common made no attempt to commence a systematic survey of the heavens.

Mr. Isaac Roberts, of Liverpool, was also early at work in the same field, and after preliminary experiments he acquired a powerful telescope, with which he began a systematic survey of the northern heavens.

It required some time to find the necessary means and apparatus to begin the realization of my ideas at the Cape, but at last the work was started in the beginning of 1885 on the following definite plan, viz. to complete the cartography of the heavens from 20° south of the Equator to the South Pole, and so as certainly to include all stars to the 9th magnitude.

The reasons for the adoption of this plan were the following:—

The celebrated astronomer Argelander charted the heavens on this scale from the North Pole to the Equator, and the work has recently been extended to 20° south of the Equator by Schönfeld, the pupil and successor of Argelander.

Argelander's 'Durchmusterung,' as it is called, has furnished, ever since the date of its publication, the nomenclature of all the fainter stars employed in the daily operations of astronomy; it has furnished the working catalogues which are essential for the more exact determination of the places of all these stars; it has given us the first accurate data for determining the distribution of the stars according to magnitude and apparent position in the heavens, and is the first solid existing basis for founding any theory as to the constitution of the stellar universe. To complete the 'Durchmusterung' for the remaining portion of the heavens was therefore the most pressing need of modern astronomy. I commenced the work in 1885 by the aid of photography. I hope in two or three years, if I have the honour of lecturing again in this theatre, I shall then be able to tell you that the work in question is finished.

I should here explain that mere pictures of the stars are of comparatively little value, or rather of about the same value to an astronomer as a series of charts of parts of the world would be to a sailor if there were no lines of latitude or longitude marked upon them.

The every-day useful part of the 'Durchmusterung' is the catalogue giving the positions and magnitude of all the stars. That work is rapidly advancing in the hands of my able and enthusiastic friend, Professor Kapteyn of Groningen, who, with the aid of three assistants, has undertaken to devote five or six years of his life to the measurement of the Cape photographs and the computation of the results.

When this has been finished, as I venture to think it also will be within five years, astronomers will be in possession of that preliminary survey of the whole heavens which is necessary for the more refined and elaborate researches which must follow as results of the Paris Congress.

[To be continued.]

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Colour of Achernar.

GENTLEMEN,—

The recent interesting discussion in the 'Observatory,' of the supposed change in the colour of *Sirius*, may perhaps excuse the following account of a rather remarkable instance of difference in the determinations of the colour of a bright star by different observers.

I was considerably surprised a day or two ago to find the bright, first-magnitude star *α Eridani* included in Mr. Chambers's "Working Catalogue of Red Stars," published in the April number of the 'Monthly Notices,' as being "red," because my own impressions of the colour of this star had been entirely different. It is also No. 28 of Birmingham's Catalogue of Red Stars, and in the notes to this Catalogue is described as "roth," on the authority of Engelmann, and with the reference to A. N. 1828. In 1886 *Achernar* was examined by me for colour on two occasions, with the following results:—On Feb. 9th of that year, with a 2¾-in. refractor, the star, when rather low down, was called "flushed white;" and on Feb. 28, with an opera-glass, it was described as "silvery white." In the 'Uranometria Argentina,' Gould remarks that "*Achernar* is at present a white star without apparent tinge of any sort." These later observations are all so entirely different from Engelmann's description of "roth," that any additional estimations of the colour of the star would be of much value, especially if made at about the same period as his observation. Are there any such in existence? It would obviously be of importance to know also under what conditions, instrumental and atmospherical, Engelmann's observation was made. I have not immediate access to the no. of the A. N. in which it appeared. Perhaps some one better favoured will kindly give the necessary information.

Yours faithfully,

A. STANLEY WILLIAMS.

West Brighton,
1887, May 23.

P.S.—The following errata in the 'Observatory' for April had escaped my notice. In the table of transits on p. 193, Mar. 29, $15^h\ 25^m$ should be $13^h\ 25^m$; April 21 should be April 20.

Jupiter and Lalande 25797.

GENTLEMEN,—

The star Lalande 25797 = Lamont 1448 had a narrow escape from occultation by the planet Jupiter in the night of the 21 instant. By means of the 8-inch equatoreal and the filar micrometer I obtained ten excellent transits of the star and the planet's first limb, with corresponding measures of difference of declination of the star and the south limb. The planet's opposition took place only two hours previously to the observations, so that both the east and west limbs appeared equally sharply defined. The resulting coordinates of the planet's centre, uncorrected for parallax, are:—

April $21^d\ 10^h\ 59^m\ 20^s$ Windsor Mean Time (Planet—Star) $\Delta\alpha = +5^s{\cdot}98, \Delta\delta = -4''{\cdot}7$. From these results, the semidiameter of the planet, and its hourly motion as given in the Nautical Almanac, it would appear that at conjunction in right ascension about five hours later the star would be seen a little off the planet's south limb. The star was of a pale blue colour as contrasted with one of the satellites very close to it, which presented a yellowish tinge. The sky shortly afterwards became overcast. JOHN TEBBUTT.

Windsor, N. S. Wales,
1887, April 25.

Lalande 18069.

GENTLEMEN,—

On July 11th last year I made micrometer comparisons of Comet V. 1886 (Brooks No. 1) simultaneously with four stars, one of which I could not find in any of my catalogues. The three other stars were Nos. 18013, 18030, and 18069 of Lalande's catalogue, and of these the last gave for the right ascension of the comet a value greater by more than two seconds of time than that yielded by the others. At the close of my observations, published in No. 2768 of the 'Astronomische Nachrichten,' I hinted at a considerable proper motion in the right ascension of No. 18069; and it appears, from a remark in the same publication, that Dr. Kuntz had already, from a comparison of positions given by Lalande, Bessel, and Santini, suspected a not unimportant proper motion. I availed myself of the opportunity during the present month for observing this star with the 3-inch transit instrument in the meridian, and the following are the separate results for mean right ascension for 1887·0:—

		h	m	s
April	9	9	3	24·51
„	10	9	3	24·57
„	15	9	3	24·69
„	19	9	3	24·65
	Mean	9	3	24·61

Adopting the approximate position of the star for the middle epoch, 1843·5, and Peters' elements for the same time, I get $+2^s{\cdot}9039$

for the annual precession in R.A. The R.A., brought up from Lalande's Catalogue to 1887·0 by this precession, is $9^{\mathrm{h}}\ 3^{\mathrm{m}}\ 26^{\mathrm{s}}{\cdot}89$, which exceeds the recently observed value by $2^{\mathrm{s}}{\cdot}28$. I have neither Bessel's nor Santini's catalogues in my observatory, so that I am unable to compare their positions with those for the extreme years. Some of your readers can, doubtless, supply the intermediate coordinates as given by the last-mentioned two astronomers.

Windsor, N. S. Wales,
1887, April 26.

JOHN TEBBUTT.

28 *Andromedæ.*

GENTLEMEN,—

My first suspicion of variability in this star was on the 30th November, 1886, when it struck me as looking brighter than I thought it usually was. A careful examination of my observations gives only small evidence of variability.

The comparison stars used, and their assumed magnitudes, are as follows:—

ε Andr.	4·39
τ ♓	4·58
ψ Peg.	5·07
78 Peg.	5·08
82 ♓	5·11
σ ♓	5·34

These magnitudes are taken from the average of all authorities given in the Harvard 'Annals,' together with the 'Uranometria Oxoniensis,' but modified so as to bring them into accordance with the average of my observations.

The resulting magnitudes of 28 Andromedæ are given in the following Table:—

	Magnitude.	Weight.
1886, November 30.	4·98	10
December 2.	5·18	10
December 23.	5·18	10
December 24.	5·20	10
1887, January 29.	5·16	8
January 30.	5·22	10
February 11.	5·17	3
February 14.	5·11	4
February 19.	5·26	10
February 21.	5·30	10
February 28	5·13	4
March 13.	5·27	3

The differences shown are slight, and are probably no greater than may be caused by errors of observation, with the exception of the first, which seems too great to be so accounted for. I am unable to see any evidence of the period being short, or of the star being of the Algol type, as suggested by Mr. Espin; indeed my own idea was that its variation was more likely of the contrary character, and that it might have been affected by a temporary increase of brightness, in the same way as the temporary stars are. This idea occurring to me on the 1st of December 1886, I examined the star's spectrum with one of Browning's miniature spectroscopes on a 4½-inch refractor, but could not see anything remarkable in it.

Sunderland, 1887, June 2. T. W. Backhouse.

Proposed Nomenclature for Star-colours.

Gentlemen,—

I notice a letter with above heading in the June number of the 'Observatory,' and should like to make a few remarks in reference thereto. And, in the first place, I would thank Mr. Backhouse for his friendly criticism, because it enables me to touch upon several points which were insufficiently dealt with in my paper to the R. A. S.

As to the complementary tints. The diagram was so arranged as to place the spectrum colours at equal intervals around the circle; the intermediate divisions being occupied by the subordinate tints derived from them. Then, finding orange and blue came exactly opposite, I inadvertently assumed the other complementaries to do likewise, on a symmetrical plan. I discovered the mistake afterwards (but too late to rectify it) when consulting a work on my shelves. However, the remaining complementaries require shifting one division, the opposed pairs being then as follows:—

$$R+BG : Y+BP : YG+V : G+PR.$$

After all, this was but a minor detail in my scheme; and so it may as well be omitted, as it does not affect the utility of the plan in other respects.

With regard to the definition of violet as a "bluish-purple," I certainly dissent from Mr. Backhouse. I have always understood violet to be a primary colour; and cannot conceive of its being bluish-purple, which would imply that it was compounded of these two tints. It was a moot point with me, when fixing upon the names to be adopted, whether I should say "purplish-red" and "bluish-purple," or "violet-red" and "bluish-violet"; but euphony and popular usage decided me in favour of the former. To be strictly consistent, I ought to have kept the other terms; and I now regret not having done so. But as a regular series of observations on star-colours, in which the new nomenclature is employed, has been for some time in progress (by myself and others), I do not think it expedient to make alterations which would lead to inevitable confusion. So far, the proposed system has worked well, in the hands of several observers; and the ease with which the independent estimates can be reduced to mean results is, I venture to submit, a practical proof of its superiority over the old plan of arbitrary names and vague descriptions. I have not met with Prof. Rood's book, and so am in total ignorance of how far his plan of arranging the colours agrees with mine, but will try to get a sight of it by-and-by.

I may now supplement my paper in the 'Monthly Notices' by giving the approximate equivalents of the tints in grade 1, such being understood as white with the smallest discernible trace of colour:—

R′ = ruddy white.
OrR′ = cinnamon "
Or′ = creamy "
OrY′ = chrome "
Y′ = yellowish "
YG′ = olive "
G′ = greenish white.
BG′ = glaucous "
B′ = bluish "
BP′ = purplish "
V′ = lilac "
PR′ = pinkish "

In actual practice I find it difficult to distinguish more than about half of these delicate tints that differ so little from each other; but the scheme would scarcely have been complete without them, and other observers may be more fortunately gifted in their appreciation of minute traces of colour.

Respecting the suitability of the incandescent electric light, I spoke from a considerable experience of its use in my observatory; and I think the drawbacks to its application, if there are any, can be readily surmounted. With a good constant battery, such as may be obtained at the present time, its variations of intensity are very small, and would not, I believe, seriously affect the relative tints seen by it. I might add that Prof. Piazzi Smyth, in his 'Madeira Spectroscopic,' speaks highly of its efficiency in colour work. And I was able, when trying the experiment some time ago, to see Admiral Smyth's chromatic diagram nearly as well by its aid as in daylight.

Yours faithfully,
W. S. Franks.

NOTES.

Madras Meridian Circle Observations.—This volume contains the results of the Meridian Circle Observations made during the years 1862, 1863, and 1864, which Mr. Pogson has at length been able to publish. We are given no very definite information as to the reason of this great delay, but in a letter addressed to Sir M. E. Grant Duff, late Governor of Madras, which stands at the beginning of the volume, Mr. Pogson speaks of "the removal of certain arbitrary and suppressive restrictions" as having enabled him to proceed with the publication of the Madras Observations. The Transit-circle with which the observations were made has an object-glass of 5½ inches aperture and a circle of 42 inches diameter, and was brought into use in May 1862. The objects selected for observation were the brighter stars down to the 5th magnitude, the Moon and moon-culminating stars, Mars and the stars observed with him at successive oppositions, minor planets, and as many anonymous stars of more than 120° N.P.D. as could be found, not less than the 8th magnitude. The volume before us contains the results of star observations only, and exhibits the star ledgers and annual catalogues in separate form. As these separate annual catalogues are now of very doubtful utility, on account of the unprecedented delay in their publication, it would, we think, have been a much wiser and more economic plan to have printed the separate annual results and the combined general catalogue in one volume, as was done in the case of the First Armagh Catalogue and the Glasgow Catalogue, than to issue successive volumes of annual results to be followed by the general catalogue. The latter is the only volume of the series likely to be of use, and its further delay is much to be regretted.

ROYAL OBSERVATORY, GREENWICH.—The Report of the Astronomer Royal to the Board of Visitors, referring to the year ending May 20, 1887, was read at the Annual Visitation on June 4. The regular subjects of observation with the transit-circle throughout the year have been the Sun, Moon, planets, and fundamental stars, with other stars from a working catalogue. On the conclusion of the observations for the ten-year catalogue at the end of 1886, a new list of some 3000 stars was prepared to include all the stars in Groombridge's Catalogue and in the Harvard Photometry which had not been observed at Greenwich since 1867. It is estimated that the ten-year catalogue will contain about 4000 stars, the total number of observations being about 40,000 in each element. The number of transits observed during the year with the transit-circle was 6366, and the number of circle observations 5983. Five determinations of the flexure of the transit-circle have been made since the last Report, the resulting values being $-0''\cdot16$, $+0''\cdot13$, $-0''\cdot15$, $-0''\cdot17$, and $-0''\cdot13$. It has been considered better not to apply any correction for flexure, as distinct from the the R−D correction. The value of the latter correction for 1886 is $+0''\cdot006+0''\cdot731 \sin Z.D.$ The value found for the co-latitude from the observations of 1886 is $38° \; 31' \; 22''\cdot03$; the correction to the tabular obliquity of the ecliptic is $+0''\cdot65$; and the discordance between the results from the summer and winter solstices is $-0''\cdot25$. The mean error of the Moon's tabular place (computed from Hansen's lunar tables, with Newcomb's corrections) is $+0^{s}\cdot029$ in R.A. and $+0''\cdot34$ in longitude. The mean error of tabular N.P.D. is $-0''\cdot66$. The south-east and Sheepshank's Equatoreals are in good order. Observations of comets have been continued with the latter instrument, whilst with the former determinations of the motions of stars in the line of sight have been made as in recent years. The observations of Sirius since the date of the last Report indicate that the apparent displacement of the F line (which was originally towards the red and subsequently towards the blue) is now insensible. The displacement of the F line in the spectrum of Algol has been measured as frequently as possible during the winter months, in order to ascertain if any evidence could be obtained of rapid orbital motion such as would result from the hypothesis of the variability of Algol being caused by the transits of a large satellite. There are indications of a variation of the motion in the line of sight corresponding to orbital motion, having the same period as that of the star's variability.

A photographic corrector, consisting of a concave crown and convex flint lens (in contact), placed about 30 inches within the focus, has been applied to the telescope of the South-east equatoreal to correct the chromatic aberration of the object-glass for the photographic rays without alteration of the focal length. A Dallmeyer doublet (formerly used in the photoheliograph) has been employed to enlarge the primary image about 7½ times, so as to give on the photographic plate an image on a scale of about 0·45 in. to one minute of arc, or 15 inches to the Sun's diameter. A number of trial photographs of Castor, γ Virginis, Venus, Jupiter, and Saturn have been obtained. The photographs of the double stars appear to be susceptible of very accurate measurement, and several of the photographs of Jupiter show the four satellites, the belts, and the red spot. A photograph of γ Virginis, showing the components widely separated, has also been taken at the primary focus, the Dallmeyer enlarging-doublet having been removed.

In the twelve months ending 1887 May 20, photographs of the Sun have been taken at Greenwich on 215 days, and of these 421 have been selected for preservation, besides 16 photographs with double images of the Sun for determination of zero of position.

The areas of both spots and faculæ have continued to decline through 1886 and 1887, the Sun being free from spots on 61 days in the year 1886. In the period of 150 days from 1886 October 30 to 1887 April 17 on which photographs are at present available, there were 73 days on which no spots were visible on the Sun. Since April 17 there has been a revival of activity. As in 1885, the mean spotted area of the northern hemisphere has been much smaller than that of the southern.

THE ECCENTRICITIES AND INCLINATIONS OF THE ASTEROIDAL ORBITS *.—Prof. Kirkwood points out in this paper that the average eccentricity of the 264 asteroids whose orbits had been calculated at the time of writing is 0·157. This is about equal to the mean eccentricity of Mercury, and exceeds the maximum of any other major planet. These large eccentricities (which do not appear to vary with the distance from the Sun) seem to indicate that the forms of the asteroidal orbits were influenced by special causes. With regard to the inclinations, Prof. Kirkwood finds that 152 minor planets have inclinations between 3° and 11°, and that the mean of the whole number is about 8°, the smallest inclination, that of Massalia, being 0° 41′, and the largest, that of Pallas, about 35°. Proceeding to discuss the question whether there is any relation between high inclinations and great eccentricities, Prof. Kirkwood points out that 15 minor planets have inclinations exceeding 20°,

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* 'The Sidereal Messenger,' May 1887.

and of these all but two have large eccentricities. On the other hand, however, over 50 asteroids with eccentricities exceeding 0·2 are not found to have extraordinary inclinations, so that the forces which produced the great eccentricity failed in a majority of cases to cause high inclinations.

THE BAMBERG OBSERVATORY.—The following particulars respecting this new observatory are given by Dr. Hartwig in a letter to Col. Tupman.

"This observatory," Dr. Hartwig says, "was founded by an amateur astronomer, Dr. Carl Remeis, who died in 1883, and building operations will be commenced this spring. 180,000 marks have been apportioned for its erection, and 70,000 marks for instruments. For properly maintaining and conducting the institution 50,000 marks will be taken from revenues due from the estate, while the same source will provide 80,000 marks for salaries to the astronomical staff, and 20,000 marks for that of the keeper &c. Besides these sums there is a reserve fund of 50,000 marks. The post of chief astronomer will be filled by the nominee of the Philosophical Faculty of the Munich University from the Royal Bavarian College.

"The apparatus necessary for the equipment of the observatory will, primarily, consist of:—

"(1) A heliometer, aperture 7 English inches, by Repsold, similar to that recently furnished to the Cape Observatory, with which, moreover, it will undertake work in common.

"(2) A reflector, already at hand, 10-inch aperture, by Schroeder, with filar micrometer by Repsold.

"(3) A transit instrument, 30 Paris lines aperture, with horizontal circle after Döllen, by Repsold, object-glass by Merz.

"(4) A comet-seeker, 6-inch aperture, with stand, and with altitude and azimuth circles (like that in Strassburg), object-glass by Merz.

"We already possess a telescope, 4-inch aperture, by Reinfelder and Hertal; two universal instruments by Ertel and by Becker; a telescope by Fraunhofer, 34 Paris lines aperture; a comet-seeker, 3-inch aperture, by Merz.

"Should we be successful in our efforts to obtain a grant from Government, we intend to procure a 6-inch meridian circle.

"No funds have been assigned for a library; as far as this is concerned, the observatory is dependent on the liberality of other scientific bodies, sister institutions, &c.

"The heliometer (the largest in the northern hemisphere) will be used for systematically investigating the parallax of the fixed stars in common with Gill and Elkin; the physical libration of the Moon will also be subjected to inquiry.

"The building will consist of two towers (from which the observations will be made), connected by a passage with a dwelling-house, which will contain, in addition to the usual residential accommodation, the work-rooms, viz. computing-room, library, workshop, and laboratory.

"The designs for the construction of the observatory have been furnished by a Strassburg architect, Herr Issleiber, who was instructed by Herr Eggert, the builder of the Strassburg Observatory.

"A hill, with fine rocky soil 6½ metres deep, has been chosen for the site of the observatory.

"The accumulators necessary for the electrical illumination of the instruments will be supplied by the water power at the foot of the hill. The ridge of the hill lies 36 metres above the surface of the river flowing below. As soon as the actual building operations shall have commenced, I think of publishing a short account of the undertaking in the 'Astronomische Nachrichten.'

"ERNEST HARTWIG."

THE PARIS OBSERVATORY.—M. Mouchez has published his report, as Director of the Paris Observatory, for the year 1886. The principal meridian work during the year was the observation of Lalande's stars (a work now approaching completion), to which the great meridian instrument and the Gambey circle were devoted. A grand total of 16505 observations were made with these instruments during the year. 798 observations of planets were obtained, including 148 of the Sun and 128 of the Moon. The garden meridian circle was reserved for researches connected with M. Loewy's method for determining the position of close circumpolars ('Observatory,' vol. viii. p. 313). With the equatoreals, observations of comets, minor planets, nebulæ, eclipses of Jupiter's satellites, and occultations of stars by the Moon have been obtained. The MM. Henry have continued their work in the department of astronomical photography during the year with marked success. They have obtained numerous photographs of Jupiter and of the Moon, as well as 47 plates of different regions of the sky. Ten photographs of Præsepe have been taken, which it is proposed to utilize for accurate measurement of the relative positions of the stars of the group. Double stars and star-spectra have also been successfully photographed. M. Mouchez was awaiting the meeting of the then approaching Photographic Conference before deciding on a plan for the measurement and reduction of the stellar photographs. Some measures of photographs of well-known double stars, made with the macro-micrometer designed by MM. Henry, are appended to the report. The measures made with this apparatus are, M. Mouchez says, of remarkable accuracy; thus, for ζ Ursæ Majoris, the mean error of a single measure of distance is $0''\cdot077$, and of position-angle $0^\circ\cdot55$. It is hoped that, during the current year, it will be possible to provide the necessary apparatus for the carrying out of M. Loewy's plan for determination of the constants of refraction and aberration ('Observatory,' vol. ix. p. 108, and vol. x. p. 196), with the great importance of which M. Mouchez appears to be thoroughly impressed.

A NEW MINOR PLANET (No. 268) was discovered on June 9 by M. Borelly, at Marseilles. It was of the 12th magnitude.

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A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY
E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Annual Meeting of the Liverpool Astronomical Society 281

Articles :—

The Applications of Photography in Astronomy. By DAVID GILL, LL.D., F.R.S., &c. 283
Observations of Comet 1886 *e* (Finlay). By H. C. RUSSELL, B.A., F.R.S. ... 294
Braun's Theory of the Sun. By the Rev. W. J. CROFTON 295
Selenographical Notes. By T. G. ELGER, F.R.A.S. 298
Meteor Notes. By W. F. DENNING, F.R.A.S. 299

Correspondence :—

Proposed Index to Observations of Variable Stars. By EDWARD C. PICKERING, For. Assoc. R.A.S. 301
Achernar. By G. F. CHAMBERS, F.R.A.S. 301
Observing-weather during Transit of Venus. By the Rev. S. J. JOHNSON, F.R.A.S. 302
Remarks on the 'Canon der Finsternisse.' By the Rev. S. J. JOHNSON, F.R.A.S. 302
Noises accompanying Auroræ. By R. RENDALL 303

Notes :—

The Continental Observatories.—The Almucantar.—The Total Solar Eclipse of 1886.—The Parallax of α Tauri.—The Oxford University Observatory.—Variations in the Sun's Diameter........ 304–308

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CONTENTS OF No. 125.

Page
Meeting of the Royal Astronomical Society on June 10 249

Articles:—

Sweeping for Red Stars and Stars with Remarkable Spectra. By the Rev. T. E. Espin, B.A., F.R.A.S. 25
Maxima and Minima of Variable Stars observed during the Year 1886. By Joseph Baxendell, F.R.S., F.R.A.S. 261
Maxima and Minima of Variable Stars observed during 1886. By Joseph Baxendell, Jun. 26
The Companion of Sirius. By Prof. C. A. Young, Ph.D., For. Assoc. R.A.S. 26
Selenographical Notes. By Thos. Gwyn Elger, F.R.A.S. 263
Meteor Notes. By W. F. Denning, F.R.A.S. 265
The Applications of Photography in Astronomy. By David Gill, LL.D., F.R.S., &c. 267

Correspondence:—

The Colour of Achernar. By A. Stanley Williams, F.R.A.S. 27
Jupiter and Lalande 25797. By John Tebbutt, F.R.A.S. 27
Lalande 18069. By John Tebbutt, F.R.A.S. 27
28 Andromedæ. By T. W. Backhouse, F.R.A.S. 274
Proposed Nomenclature for Star-colours. By W. S. Franks, F.R.A.S. 27

Notes:—

Madras Meridian Circle Observations.—Royal Observatory, Greenwich.—The Eccentricities and Inclinations of the Asteroidal Orbits.—The Bamberg Observatory.—The Paris Observatory.—A New Minor Planet...276-28

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 126. AUGUST. 1887.

Annual Meeting of the Liverpool Astronomical Society.

By the permission of the President and Council of the Royal Astronomical Society, the Annual General Meeting of the Liverpool Astronomical Society was held on July 8 at the rooms of the Royal Astronomical Society at Burlington House. There was a large attendance of Members. The President, the Rev. T. E. Espin, took the chair at 3 P.M. The minutes of the preceding meeting having been read and confirmed, Mr. Wesley read the report of the Auditors (Mr. W. H. Wesley and Mr. H. Sadler), from which it appeared that the Society has a small balance in hand.

In reading the Annual Report of the Council, the Secretary, Mr. W. H. Davies, stated that very satisfactory progress had been made during the past session, no less than 231 Members and 11 Honorary Associates having been elected, making a grand total of 440 Members and Associates. A most important branch had been formed by the constitution of the Pernambuco Branch of the Society, consisting of 111 Members, including the Emperor of Brazil as Honorary Associate. Associate branches in Western and Southern Australia were also in course of formation. Upwards of 150 valuable books and pamphlets had been presented to the Society during the past session, and a catalogue of the library is in process of formation. Special acknowledgment was due to the valuable work performed by the Sections. The Lunar Section has undertaken the systematic study of some of the most remarkable formations on the Moon, with a view to map and catalogue the details they include. It is hoped that before long it will be practicable to undertake the mapping of portions of the lunar surface on a much larger scale than has as yet been attempted. A second section has undertaken the systematic study of the colours of stars, and some 750 of the brightest stars have been examined with that end in view, while Birmingham's Red-Star Catalogue is in course of revision. In the Variable-Star Section a close watch has been kept on suspected variables, and it is proposed to examine double stars in which a variation of light is suspected. In the Double-Star Section measures of some 50 pairs have been published; and it is hoped that the remainder of the first series of measures of 200 double stars will be ready for publication by the end of the year. The work of the Meteoric Section has been very actively pushed forward, and upwards of 300 observations have been recorded. It is hoped that by the end of the year a catalogue of about 1000 radiant-points will be ready for publication. Owing to the scarcity of sun-spots during the last year, the Solar Section has but little to report. A set of disks has been published for determining the positions of sun-spots. The Planetary Section has been divided, two subsections (one devoted to the study of the planet Jupiter, the other to that of Saturn) having been created. The red spot and the markings on the planet Jupiter are at present being carefully watched, and a report, embodying the chief results obtained, will be drawn up for the Society at the first meeting in the autumn. A series of illustrated papers on this subject will be published throughout next session. It is intended to devote special attention to the apparent rapid changes in the details of the ring-system and the shadow of the ball on the rings of the planet Saturn. The Comet-seeking Section will commence systematic work in August. An educational Section has been formed for the purpose of relieving the strain upon the other sections, by assisting the beginner until he becomes sufficiently advanced to take a satisfactory part in the work of some particular section. This department will include instruction in the general outlines of astronomy, and in elementary optics so far as relates to telescopic and spectroscopic work. The report concluded by tendering the warmest thanks of the Council to the Council of the Royal Astronomical Society for their courtesy in permitting the Annual Meeting to be held in their rooms.

The Rev. T. E. Espin read the Observer's report. He said that a large number of Members had availed themselves freely of the means of verifying observations afforded them under sections 1 and 2 of bye-law xi., and the correspondence had been heavy; in every case, however, the large aperture of the telescope had enabled him to verify the observation. The work done under section 3, which states that the Observer shall undertake some systematic work for the Society, has been chiefly searching for red stars and reobserving those already known, with a view to the new edition of Birmingham's Red Star Catalogue, which is now well in hand. Up to the present time over 220 new red stars had been discovered. In November last a spectroscope was devised capable of showing star-spectra to the 9th magnitude, and now every new red star detected was observed with the spectroscope as well. During the past year 87 stars with remarkable spectra of type iii., and 23 of type iv., were detected. A description of the spectroscope has been published in the 'English Mechanic.' Some of the results of the work done had been published privately, and most of the later observations in the pages of the 'Astronomische Nachrichten.'

The usual variable-star observations had been forwarded to Harvard College, and are now in print. Two long-period variables had been discovered, and a new star of the 7th magnitude in Cygnus, which has now faded to below the 10th magnitude.

It was resolved that the reports of the Council and Special Observer should be printed in the 'Journal' of the Society.

A somewhat desultory conversation ensued on the question of the abolition of the post of Special Observer and the adoption of a common seal for the Society; and in the end both questions were deferred for the further consideration of the Council.

Thanks were voted to the Auditors, contributors to the Journal, Directors of Sections, the President, the Scrutineers of the Ballot, and to the Council of the Royal Astronomical Society for the use of their rooms.

The following members and honorary associates of the Society were declared elected as Officers and Council for the coming year:—*President*, Mr. Denning; *Vice-Presidents*, Mr. Elger, Rev. T. E. Espin, Mr. Gore, and Mr. Newall; *Special Observer*, Mr. Gill; *Editor*, Mr. Sadler; *Librarian*, Mr. Defieux; *Secretary* and *Treasurer*, Mr. W. H. Davies; *Council*, Miss E. Brown, Majors Markwick and Watson, Messrs. Backhouse, Calver, Deane, Gill, Higgs, Lynn, Monck, Oliphant, and Tarrant. As representatives for the Pernambuco Branch, Messrs. Elger and Franks. *Directors of Sections*—Solar, Miss Brown; Lunar, Mr. Elger; Meteoric and Comet-seeking, Mr. Denning; Coloured Star, Mr. Franks; Double Star, Mr. Tarrant; Variable Star, Mr. Gore; Educational, Mr. Gill; Planetary (Jupiter), Mr. Denning.

Mr. Wassell read a paper, illustrated by diagrams, on "Methods of working and testing Specula."

The Meeting adjourned at 5.30 P.M.

The Applications of Photography in Astronomy.

[Continued from p. 272.]

BUT to return to the work that was meanwhile being done in Paris by the brothers Paul and Prosper Henry.

These astronomers had been engaged since 1871 in the construction of charts of the Ecliptic by the older processes of observation, but when they reached that portion of the heavens where the Milky Way crosses the Ecliptic, the number of stars became so overwhelming that the task of charting seemed almost too great for human patience and skill. But fortunately the time had come when dry-plate photography could be called in to aid, and this aid was in the hands of men singularly competent to develop such an opportunity to the fullest extent. The brothers Henry had long aspired to be not only distinguished practical astronomers, but, following the traditions of Huyghens and the Herschels, they desired also to be the artists of their own optical means. Bound together by strong brotherly affection and common tastes, gifted alike with practical talents of a high order, and with an energy and determination of character that permit no obstacle to success, these men thus happily united have devoted the spare hours of their busy astronomical duties at the Paris Observatory, first to the study of optics, and afterwards to the grinding and polishing of lenses and specula, which have won for them a now world-wide reputation as opticians of the highest rank.

I had the pleasure, a few weeks ago, of visiting the modest workshop attached to their house at Montrouge, and I shall not soon forget that visit, nor the many lessons moral as well as practical which I learned.

Every detail of their process of working has been evolved by themselves; they employ no assistant, and their every appliance is simple and practical in a degree which I can only compare with the simple and practical character of the men who designed it.

Such were the men above all others to develop the application of photography to the charting of the heavens. They had high appreciation of the value of the work which they were about to undertake, they had the fullest knowledge of the requirements of the case, and they had the practical skill which enabled them to perfect the necessary apparatus. Their first attempts were made with a telescope of six inches aperture (the object-glass being specially ground for photographic work), and the tube was temporarily adapted to an existing equatorial stand.

With an exposure of forty-five minutes, pictures of stars were obtained to the 12th magnitude, in which the star disks were quite round and sharply defined.

Fully appreciating the beauty of this result, and seeing its importance, Admiral Mouchez boldly faced many administrative difficulties, and accepted without delay the proposals of the brothers Henry to construct an object-glass of thirteen inches aperture and about 11 feet focal length, as well as the offer of M. Gautier to mount the same on a suitable stand. The new instrument was mounted in May 1885. A photograph of the complete instrument is now on the screen.

Both from an optical as well as a mechanical point of view, the new instrument was admirably adapted for its intended work, and the results obtained by the brothers Henry, and rapidly published and circulated by Admiral Mouchez, at once astonished and delighted the astronomical world.

I now show a few of the more remarkable of these star pictures on the screen.

After such results as these there was no longer room for doubt or delay. The exquisite precision of these pictures, the sharpness and roundness of the images of the stars, and the results of actual measurement on the plates, proved that all necessary accuracy had been attained.

The means of rapidly obtaining the data for an accurate survey of the heavens on a very large scale were now within the reach of astronomers, and the time for decisive action had arrived.

The work, however, was too extensive to be undertaken at a single observatory, or even by a single country, and it was agreed on all hands that international co-operation was essential for its execution in a sufficiently short space of time.

I need not enter into the details of preliminary consultation or correspondence, but at last a time was fixed, and invitations were issued by Admiral Mouchez, Director of the Paris Observatory, under the auspices of the Paris Academy of Sciences, for an International Congress of Astronomers to be held at Paris.

A preliminary committee having arranged the general order of business, the Congress was opened on the 16th April, and its thoroughly representative character will be understood from the following statement of the nationalities of the members present:—

France	20	U.S America	3	Spain	1
England and Colonies	8	Austria	2	Switzerland	1
Germany	6	Sweden	2	Portugal	1
Russia	3	Denmark	2	Brazil	1
Holland	3	Belgium	1	Argentine Republic	1
		Italy	1		

Before the Conference, a great many people, I will not say astronomers, held that the chief object was to photograph as many stars as possible, and simply preserve these plates or issue photographic copies of them, so that astronomers of the future, by merely comparing one of these originals or copies with a similar photograph of the same part of the sky taken 50 or 100 years hence, would find out what stars had changed in position or magnitude, or whether any new star had appeared.

There is no doubt this was the view of the popular writers—it is very easily understood, and it appeals very directly to the imagination. Such a project alone would no doubt have had great importance, and would probably in the future have brought to light a great many very interesting isolated facts.

But for the broader and more refined purposes of astronomy, for the discussion of such great questions as the motion of the solar system in space, the common movement of large groups of stars, the accurate determination of precession, and the general refinement of astronomy of precision, these mere pictures would have no value.

It was essential for these larger and more permanently important ends that all data should be provided for the most refined determination of the *absolute* position of any star upon any plate. This view was endorsed by the Congress.

The objects of the survey of the heavens to be carried out were defined ultimately thus:—"To make a photographic chart of the sky for the present epoch, and to obtain the data for determining the positions and magnitudes of all the stars to the 14th magnitude," as that magnitude is at present defined in France.

At present there are no exact determinations of stellar magnitude to that order of faintness, and the considerations which really guided the Conference were, that stars which are called 14th magnitude are photographed by the Henrys with an exposure of about 15 minutes of time. With such an exposure the time required for the work contemplated by the Congress would not be too great, but to demand long exposures would lead to the loss of many plates by interruptions from clouds, &c., and would unduly prolong the time required for completion of the whole work. As it is, the number of stars photographed to 14th magnitude will number about 20 millions.

It was seriously urged that stars to the 15th or even 16th magnitude and higher should be photographed, but it was felt that there was real danger of failure in an attempt to do too much.

It no doubt produces a strong effect on the imagination to be told that astronomers are to be engaged on making charts of the sky which will contain 60 or 100 millions of stars, or photographing stars on their plates which cannot be seen at all in the most powerful telescopes. There is thus a strong temptation to yield to this demand for sensation, to produce a few astonishing plates with the loss of much precious time, and to sacrifice the real progress of astronomy to the love of the marvellous. Besides, what are you to do with pictures of 100 millions of stars when you have got them? What would be the use of pictures of all these stars, unless at some future time a sufficient number of astronomers were to arise to compare similar photographs, taken, say, one hundred years hence, with the photographs taken in our day? I am happy to think that the number of men who devote themselves to the pursuit of astronomy is on the increase; but I have no desire that the number of men in Great Britain who occupy themselves exclusively with astronomy will ever correspond with that in the floating island of Laputa, as described by Dean Swift, where all the men were exclusively occupied with astronomy, and had to be flapped on the head with little bladders containing parched peas to arouse them from their abstract occupations. And yet, unless something of this sort happens, I see no adequate prospect of the utilization of pictures of 100 millions of stars.

The Congress, therefore, very wisely limited their chart plates to the 14th magnitude. But, as was well said by M. Bouquet de la Grye, it was not necessary to summon fifty or sixty astronomers to a Congress to arrange for taking mere photographs of stars—a number of photographers provided with instruments like the Henrys could have done all that without a congress. It was very strongly felt that the true *raison d'être* of the Conference was to secure astronomical data precise and exact, as the operations of astronomers should be.

Accordingly they resolved that:—

"In addition to the duplicate series of plates giving all the stars to the 14th magnitude, there should be a series of plates of shorter exposure to insure a greater accuracy in the micrometric measurement of the standard stars, and to render the construction of a catalogue possible. The plates intended for the formation of the catalogue shall contain all the stars to the 11th magnitude inclusive." That is to say, it was determined to catalogue the absolute places of stars to the 11th magnitude.

But no photographic plate of itself gives us any information about the absolute places of stars, though it gives the means to determine the relative positions of the stars on the limited area of each plate; you must trust to the old-fashioned meridian observations to determine the absolute places of the brighter stars on each plate, and then measure the position of the fainter stars relative to these standard stars.

Now if a plate is exposed long enough to get satisfactory pictures of stars to the 14th magnitude, the images of the standard stars of the 7th, 8th, and 9th magnitude will not have the highest perfection, and consequently the places of the fainter stars cannot be measured relative to the ill-defined standard stars with the highest precision.

This will be evident if we examine actual photographs.

One illustrates a short exposure (1 minute), the other a long exposure (30 minutes). The short exposure gives sharp definition of the brighter stars, the long exposure brings into view a much greater number of stars, but the sharp definition of the brighter stars is completely lost. Therefore if we wish to have determinations of *absolute* positions, we cannot have long exposures.

The meaning of the series of plates of short exposure, and showing stars only to the 11th magnitude, is thus explained:

Of stars to 11th magnitude there are about 1½ millions in the sky, and a catalogue containing all these stars may be considered complete for the practical purposes of astronomy, because that magnitude is the faintest which can be measured with accuracy in the larger class of equatorials usually employed in working observatories.

I need not enter into detail about the technical means which are to be taken for eliminating the various sources of error, such as contraction of the photographic film in course of development, and so forth. All these points have been considered by the Congress, or put into the hands of specialists when it appeared that any particular point required further special study, and they are too technical to be entered upon here. The chart of stars to the 14th magnitude will be of importance for many purposes, such as the search for minor planets, and the trans-Neptunian planet, for variable stars, and for data as to the law of distribution of stars of the higher order of magnitude. But I do not hesitate to say that the work which astronomers of future generations will be most grateful for, and which will most powerfully conduce to the progress of astronomy, will *not* be the chart but the catalogue.

And now, Ladies and Gentlemen, I have dragged you through what I fear has so far been a weary account, to bring you to an apparently very uninteresting conclusion.

Catalogues and figures are not matters of much popular interest, and yet from such uninviting material has been built up the fair structure of the exact astronomy of the present day; and out of such materials have been evolved the facts which appeal so strongly to the minds of men, and most strongly so because men know that the conclusions rest not on mere imaginings alone, but on solid facts and figures also.

But now as to the practical execution of this useful work. After all the preliminary details of the operations have been fully discussed—when the instruments have been designed and made, and the mode of working and the methods of measurement and reduction have been devised, the practical execution of the work becomes one long round of routine labour, requiring skilled and careful superintendence it is true, but still routine work of a very trying character.

Such work never has been, and never will be, the occupation of the amateur or single-handed astronomer. Essential as such work is to the progress of astronomy, it can only be executed at regular Government establishments, and therefore the conclusions of the Conference will have to be submitted to the various Governments, and the necessary votes of money must be secured. France has already definitely sanctioned the funds for four photographic telescopes of the kind which the Conference has decided to adopt for the work. And we cannot doubt that the modest claims which will be made on England's treasury for her share in this great work will be liberally responded to.

But there are other applications of photography to astronomy which have a daily growing importance. It was desirable that the Conference should recognize this work, and establish relations with those engaged upon it.

Accordingly the following resolution was passed:—

"The Congress expresses the desirability of there being a special committee which shall occupy itself with the applications of photography to astronomy, other than the construction of the chart. It recognizes the importance of these applications and the relations which it is desirable to establish between different kinds of work. The Congress request Messrs. Common and Janssen to undertake the realization of this proposition."

At first sight this may appear a somewhat barren resolution—but indeed it is not so. It must be remembered that the Congress was convened for the purpose of discussing a special object; it had arrived at definite conclusions and recommendations in connection with that object, and it was felt that to go beyond that object might imperil the adoption of its recommendations by the various Governments.

But in the hands of men like Common and Janssen the resolution of the Conference is not likely to be a barren one, indeed it is certain that it will not be so, for they are already taking steps to unite fellow-workers in this field.

Their Committee will associate itself with those who are engaged upon the Charts, and will follow up in detail and with special instruments and methods the subjects of interest which from time to time will be encountered by the routine workers.

So remarkable has been the progress of the miscellaneous application of photography to astronomy within the past year, that some account of it is essential to bring the history of the subject up to date.

For example we have the recent work of Professor Pritchard, of Oxford.

He has applied photography during the past year to the most refined and difficult problem of practical astronomy, viz. the determination of the annual parallax (*i. e.* the distance) of the fixed stars. He has selected for experiment the interesting double star 61 Cygni. One of the original negatives of the series is now on the screen. This star, as is well known, was selected by Bessel, on account of its large proper motion, as the most suitable star for his first experiment. It was probable, because its large apparent motion among the stars was so great, its real distance from us would be less than that of stars of less apparent motion. Bessel's observations with the Königsberg heliometer proved this to be the case, and his discussion of these observations first convinced astronomers that the measurement of interstellar spaces was a problem not entirely beyond their reach.

Prof. Pritchard has now photographed the star during a whole year, and within a few days he promises that we shall have the results of his measurements of the plates. It will be of great interest to compare his results with previous independent determinations of the parallax of the same star made by other astronomers with different means; but it will be still more interesting for the future of astronomy to compare the amount of accuracy which the photographic method affords, as compared with the older existing methods. From preliminary results published by Prof. Pritchard we are led to expect a very high accuracy from the new process.

So far, however, as present experience goes, we shall not be able to apply this new method to the measurement of the parallax of very bright stars, because, when the plates have been exposed long enough to obtain pictures of the faint comparison stars, the disks of the brighter stars become too large and ill-defined for exact measurement. It may be that this obstacle will yet be overcome, but at present it has still to be faced.

On the question of the comparative merits of refractors and reflectors as the proper instruments for photographic use, very elaborate comparison has been instituted, and much discussion has been held.

From the simple facts, that the best work yet done has been done in stellar photography by refractors, and that they are in many ways more convenient and simple in use than reflecting telescopes, the Paris Congress unanimously adopted the refractor as the instrument to be adopted for the international star charts.

But here is a very remarkable picture taken with the Oxford reflector, which shows star-disks very sharp and very round over a very large field of view, viz. eighty minutes of radius.

In the photography of special objects, such as star-clusters and nebulæ, much has been done.

Common's exquisite photograph of the great nebula of Orion you have seen before in this theatre, and for exquisite beauty of detail it has never been surpassed. But of this we may be sure that, if Mr. Common is spared in health and strength to complete the great reflector of five feet aperture upon which he is now engaged, that photograph, beautiful as it is, will be far surpassed.

Here is a photograph of the same object by Mr. Roberts. So short is the proportional focus of his telescope, so sensitive the plates he has employed, that the detail of the brighter parts has been completely burnt out; but we have faint outlying detail which is not at all shown in Mr. Common's photographs.

Here is another photograph of the same object by Professor Pickering, taken with a four-lens objective, of eight inches aperture and very short focus, and including a field of 5 degrees square. Exposure 82 min. This shows what can be done with such a combination.

In 1885 the brothers Henry, photographing the Pleiades on November 16th, discovered a new nebula, near the bright star Maia in the group. Here on the screen is a copy of the original negative by which the discovery was made. You observe the nebula like a filmy projection from one of the stars.

After the nebula had been discovered by photography it was found to be visible in the great telescope of 30 inches aperture at Pulkowa. But to *discover* is one thing, to see after discovery is another.

Strangely enough this new nebula was really photographed, a fortnight before its discovery at Paris, by Professor Pickering at Cambridge in America. In exhibiting the photograph to the National Academy of Sciences five days before Henry's discovery, Professor Pickering pointed out the "wing" attached to the star; but there was only one plate shown, and the impression was that the mark was due to a defect in the gelatine film.

Here, however, is another picture of the Pleiades taken at Cambridge with the same instrument and an exposure of eighty-two minutes, which shows nebulosity about more than one star of the group.

And here is a copy of a negative by Mr. Roberts, of Liverpool, with an exposure of three hours. The star-disks are of course large and ill-defined; but the quantity of nebula, invisible to the eye in the largest telescopes, is quite surprising.

These photographs appear to prove conclusively that the nebula and the stars in this group are one system; the doctrine of chances renders it almost an impossibility to suppose that such a symmetrical arrangement of nebulous matter with respect to the stars could exist by chance, if the stars were projected in front of a far distant background of nebulous matter.

Here is a photograph of the stars surrounding the celebrated variable star η Argus, taken at the Cape with the telescope of 9 inches aperture, generously presented to me for such work by Mr. James Nasmyth. The nebula surrounding this star is very faint compared with the Orion nebula, and it seems to be deficient in actinic rays, and, besides, the telescope is intended for stellar photography by its long focal length, and not for nebulæ, which require a shorter proportional focus—*i. e.* more intrinsically brilliant image.

Still there is the nebula, and I believe this is the only existing photograph of the object. The exposure was 2¾ hours, and yet although the original negative has been enlarged four diameters the star-disks remain well defined. The corresponding region of the sky is less than the Moon's apparent diameter, and of the many thousands of stars visible on the photograph not a single one is visible to the naked eye. The star η Argus was in 1843 nearly the brightest star in the heavens, in fact second only to Sirius; it is now between the 7th and 8th magnitude.

Here is a star-cluster in Argus. The star-disks are not so sharply defined, but the original negative has been much magnified to bring out the star-disks.

Here is a photograph, also taken at the Cape, of the wonderful star-cluster ω Centauri. It is the finest globular cluster in the heavens, and I do not know that I have ever seen the separation of the central stars so distinct with the eye as they are in this photograph. Perhaps by photographing we shall learn what motions occur in each cluster. This negative has been enlarged four diameters from the original.

Here is a photograph of the well-known cluster in Hercules, taken by Mr. Roberts of Liverpool, and a still more wonderful one by the Henrys of Paris. They must be magnified more highly to give any idea of their quality.

When the objects are bright, such as bright double stars, or planets, or the Moon, we can enlarge the image produced by the telescope, by aid of a secondary magnifier.

Because of the greater size of the original pictures thus produced, the granulation of the photographic film interferes to a less extent with the detail of the picture. Of course, this advantage is purchased at the cost of a longer exposure, because the same amount of light is spread over a larger area of the sensitive plate, and consequently the same area of the film receives less intense light, With very bright objects, such as the Sun, Moon, and planets, this is of little consequence, and may be an advantage, as permitting more accurate regulation of the exposure.

Here is a picture of the Sun photographed by M. Janssen at Meudon, near Paris. The exposure is less than 1-1000th of a second of time. And here is an enlarged photograph of the same spot, showing an amount of detail which no artist could convey by hand and eye, nor could he emulate the absolute accuracy of the photograph.

Here are some photographs of the planet Jupiter, taken at Paris, the original image being magnified 18 times.

Here is another showing the remarkable red spot—you even have before your eyes evidence of the rotation of Jupiter on its axis by the change in the position of the spot during the same evening.

This spot appeared in 1878 and measured about 30,000 miles in length by 7000 miles in breadth. It became of a deep red colour in 1879, and for the three following years was a most striking feature in the planet. It almost faded entirely in 1883, but has again become nearly as bright as it was in 1882.

Miss Clerke tells the story most admirably and suggestively in the last edition of her 'History of Astronomy,' to which work I would refer those of my hearers in whom these beautiful photographs may excite a sufficient interest.

To enter fully into the matter would demand a lecture to itself—and the minute-hand of that inexorable clock warns me that I must move on.

Here are some photographs of Saturn.

Here are some photographs of double stars. One of them, γ Virginis, taken at Greenwich, is the best photograph of a double star that I know.

Last of all I come to the most recent revelations of the power of photography as an aid to astronomy. Dr. Henry Draper, in 1872, was the first to photograph the lines in the spectrum of a star, but his admirable investigations were interrupted by death in 1882. In 1886, his widow placed in the hands of Professor Pickering, of Harvard College Observatory, in America, not only an ample sum of money for the purchase of costly apparatus, but also made a liberal provision for carrying on the work of photographic spectroscopy as a memorial to her husband. So noble a gift, and the execution of so pious a purpose, could not have been placed in abler or more active hands.

Within the past few weeks we have received the first-fruits of the Henry Draper Memorial Fund.

When I began preparation of this lecture, I cabled to Professor Pickering a request for some glass copies of his original negative. He kindly complied, and they arrived this morning. Time only permits me to show them rapidly, but those who remember Dr. Huggins's lectures on stellar spectra in this theatre, will recognize the enormous importance of such pictures as these.

The ingenuity of the adopted methods, the extraordinary success attained, the promise of rich harvest, exceeding our highest previous expectations, which the results afford, are themes upon which one could dilate for hours.

Here we have the spectra of the distant stars whose actual disks we can never hope to see, registering in these rhythmical lines the story of their constitution and temperature, with an accuracy and precision which not many years ago we should have been glad to obtain in the records of the spectrum of our own Sun.

And this is not all; not only have we such results for a few stars, but we are promised "that the complete work will include a catalogue of the spectra of all the stars of the 6th magnitude and brighter, a more extensive catalogue of spectra of stars brighter than the 8th magnitude, and a detailed study of the spectra of the bright stars." These are Prof. Pickering's own words.

What Prof. Pickering promises, we know, from long experience, that he will perform. We may also well say with him, that "a field of work and promise is open, and there seems to be an opportunity to erect to the name of Dr. Henry Draper a memorial such as heretofore no astronomer has received."

There is in England wealth enough and to spare. Many a rich man dies puzzled how to dispose of his money; and there is many a living man who would gladly give for such an object if he knew how to do so. There is field enough in astronomy, and there are men enough in England to do the work. Let us hope they will receive aid such as Prof. Pickering has received; and having done so, they will give an equally good account of their stewardship.

The miscellaneous applications of photography to astronomy offer a field so full of promise, so certain of immediate reward to those who are possessed of the necessary originality and the means to carry out their ideas, that there is more hope of private enterprise in that direction than in the more routine work of star-charting.

But tempting as these fields are, brilliant and interesting as are the discoveries to be found in them, there is in the work instituted by the Paris Congress an element that cannot be overlooked and which compels attention—it is this, the question of lapse of time. Every year that passes after that work has been carried out, increases its value and importance; every year that we neglect in doing it will be a reproach to the astronomers of the day. Into all the great problems which that work is destined to solve, the element of time enters—and time lost now in such work can never be recalled.

Of the Congress itself I would say a few last words. Its proceedings were characterized by an earnest spirit of work and entire absence of international jealousy. Our reception by the French was cordial and hospitable in the highest degree, the decisions of the Congress were almost unanimous, and were marked by a moderation and judgment which must render them acceptable to the responsible authorities of the various Governments.

Lastly, I would add that the good will which pervaded the meetings, the general success of the Congress as a whole, were in a great degree due to the general influence of the single-hearted, earnest-minded man who convened it—Admiral Mouchez.

D. Gill.

Observations of Comet 1886 e (*Finlay*).

(Made at Sydney Observatory, 1886, with the 11½-inch equatoreal and filar micrometer.)

1886, Sydney M.T.	Star.	No. Comps.	Comet—Star.		Comet's apparent		Observer.
			Δα.	Δδ.	α.	δ.	
d h m s			m s	′ ″	h m s	° ′ ″	
Oct. 26 8 56 20	1	15	+ 1 54·31	+36 37·95	18 32 4·67	−26 21 47·06	R.
Oct. 27 8 18 56	2	7	−12 30·67	− 7 57·32	18 35 42·79	−26 18 6·92	R.
Oct. 28 7 36 11	3	4	− 8 50·32	−11 58·00	18 39 23·13	−26 14 6·25	P.
Oct. 29 8 47 54	4	4	− 4 47·73	−16 37·92	18 43 25·70	−26 9 26·32	P.
Nov. 3 9 14 26	5	5	− 5 12·09	+12 41·67	19 3 22·54	−25 39 38·56	P.
Nov. 9 8 46 13	6	10	− 0 30·95	−11 14·98	19 28 37·05	−24 46 39·72	P.
Nov. 26 8 56 13	7	5	−10 8·58	− 5 25·71	20 47 48·21	−20 12 39·36	P.
Nov. 30 8 50 24	8	7	− 3 52·30	+11 0·60	21 7 43·07	−18 38 29·48	P.
Dec. 9 8 38 36	9	6	− 6 45·35	− 0 3·23	21 53 33·29	−14 25 1·45	P.

Adopted Mean Places for 1886·0 of Comparison Stars.

Star.	α.	Red. to app. place.	δ.	Red. to app. place.	Authorities.
	h m s	s	° ′ ″	″	
1	18 30 8·67	+1·69	−25 45 17·59	+ 8·48	Stone, 10131; Sydney trans.-circle, 10/4/87.
2	18 48 11·71	+1·75	−26 26 13·11	+ 8·87	Melb. 960; Cordoba Gen. Cat. 25874; Stone, 10284.
3	18 48 11·71	+1·74	−26 26 13·11	+ 8·86	Melb. 960; Cordoba Gen. Cat. 25874; Stone, 10284.
4	18 48 11·71	+1·72	−26 26 13·11	+ 8·87	Melb. 960; Cordoba Gen. Cat. 25874; Stone, 10284.
5	19 8 32·92	+1·71	−25 27 6·70	+ 9·81	2nd Radcliffe Cat. 1835; Yarnall, 8193; Stone, 10446.
6	19 29 6·29	+1·71	−24 58 5·19	+10·49	Greenwich new 7-year Cat. 2151; Stone, 10580.
7	20 57 54·99	+1·80	−20 18 18·15	+13·08	2nd Rad. Cat. 2050; Greenw. 9-year Cat. 1969; Stone, 11187.
8	21 11 33·57	+1·80	−18 27 42·51	+13·63	Cape Cat. 1850, 4251; Greenw. new 7-year, 2411.
9	22 0 16·74	+1·90	−14 25 19·81	+15·13	Greenwich new 7-year Cat. 2521; Stone, 11609.

Observations corrected for Refraction, but not Parallax. Comet faint and small; no nucleus seen. Observers: R.=Russell; P.=Pollock.

The places of the comparison stars have been taken from the modern catalogues, and the mean position derived from these has been used. The places of No. 1 found in this way were so discordant, that it was observed with the Sydney transit-circle on April 19, 1887, and the declination then found differed only 0″·06 from that given in the Cape Catalogue; the position given is the mean of the Cape and Sydney observations, the others being rejected. The reduction of these observations has been unavoidably delayed. H. C. Russell.

Sydney Observatory, 1887, May 5.

Braun's Theory of the Sun *.

The following is an abstract of Dr. Braun's theory of the Sun as set forth in his recent work on Cosmogony, which we noticed in the 'Observatory' for May, p. 200:—

According to dynamical principles, a self-attracting gaseous mass is in stable equilibrium, if the potential heat increases as we approach the surface; a contrary distribution would occasion a state of unstable equilibrium. Now, in such a gas, the pressure, to which is due the conversion of potential into actual heat, increases from the surface to the centre, and we are led to conclude that from the beginning the heat of the central portions is given out more freely than that of the outer. Owing to this cause, then, the potential heat increases as we proceed outwards, and equilibrium is stable. But in dealing with a body like the Sun, we must consider radiation, which affects chiefly the bounding layers, and diminishes their potential heat below that of the more interior regions. Such layers are in a condition of unstable equilibrium, which the least cause may disturb. The result is that, after cooling, they sink down until they reach denser strata, whilst their place is supplied by glowing masses thrown up to the surface. These last constitute the so-called "rice-grains" or "willow-leaves," whereas the descending columns form the "Réseau photosphérique," the two giving rise, by their combination, to the granulated or mottled appearance of the surface.

If we turn our attention to the chromosphere, it is clear that the hydrogen is exposed to great outward cooling through radiation, as well as to intense inward heating by the metallic vapours of the reversing layer on which it rests. Hence a constant agitation and upheaval of the lower portions above the exterior surface, in such a way as to produce the observed serrated edge. In exactly the same manner the metallic vapours resting on the photosphere are thrown into lively commotion followed by violent eruptions. Now suppose one of these fiery tongues to be shot up high into the chromosphere. The hydrogen will be intensely heated and force its way up to enormous distances, constituting what we know as a *hydrogen prominence.* By assuming a heating of from 4000° to 5000°, Fr. Braun obtains an upward velocity of 50 km. per second.

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* Ueber Cosmogonie, von Karl Braun, S.J. Münster: Aschendorff, 1887.

Similar convulsions happen at far greater depths. The central parts of the solar mass, though possessed of less potential heat, are certainly at a much higher *temperature* than more distant regions. There is then a continual flow of heat from the centre to the surface, most of which is probably devoted to raise the temperature of the descending columns of the "réseau." Any portion, however, not employed in the circulatory process will produce special heating effects, and form layers at various depths of which the total heat, potential and actual, is greater than that of the superincumbent matter. Such strata cannot be in stable equilibrium, and must give rise to disturbances. If they happen to form at great depths, especially if the rate of decrease of temperature outwards is comparatively slight, the disturbance will not be very noticeable, and it will manifest itself only as an upheaval of the photosphere. In these upheavals we witness the *faculæ.* If, on the other hand, the overheated layers are nearer the surface, and the decrease of temperature in the resisting mass is considerable, the disturbance will force its way through the photosphere, and violent discharges of glowing metallic vapours will take place. These are the *metallic prominences,* which, proceeding from great depths, where the pressure is enormous, are shot up from the photosphere with immense velocity. They subside, however, much sooner than hydrogen prominences. As soon as the excess of heat, diminished by the cooling due to expansion, is no longer sufficient to overcome their gravity and the resistances of the medium in which they move, they fall back towards the surface whence they issued.

But in their descent they give rise to a new phenomenon. The intense cooling has caused great condensation, and when they reach the photosphere they depress it by their weight, finally break through, and a *sun-spot* is formed. The opening is at first small, but into the funnel-shaped channel flow neighbouring masses of cooled metals; moreover, the sinking substances occasion the eruption of fresh matter, especially of such as is already in unstable equilibrium, so that round the spots arise new metallic prominences, which in their subsequent descent enlarge the spot or form distinct smaller spots in the vicinity. If some portions of a jet have been delayed on their way, the spot may have closed up before they reach the surface, and in consequence a new spot is seen in the same region. The prevalence of faculæ near the spots is easily explained, if we consider that the sinking masses must displace matter which is pressed upwards against the photosphere, and causes elevations or ridges. When the descending substances are exhausted, the photosphere rushes in on all sides to fill up the void, and a tumultuous wave-like encounter takes place, giving birth to fresh faculæ.

It has been noticed that new spots especially exhibit an acceleration of speed, which diminishes as time wears on. Now this peculiarity may receive some explanation by supposing that the eruptive masses take up, at least in part, the velocity of the higher beds into which they penetrate, and that accordingly, on their return, they fall in advance of the spot; thus more cold matter streams down at the head of a spot than at its rear, and there results an apparent proper motion, the velocity being more considerable at the beginning of the disturbance, when the eruptions are more numerous and attain greater heights.

According to the Cosmical theory sketched on a previous occasion, the Sun is surrounded by a broad equatoreal girdle of, say, 300 or 400 miles depth, the remains of a former much larger ellipsoidal envelope. To this view the comparatively sharp definition of the granules in the neighbourhood of the polar regions seems to lend additional weight. In ancient times the radiation at the poles would have been, in consequence, more intense than at the equator, and the cooling would have penetrated deeper into the Sun's body at the extremities of the axis. But as the temperature of the surface is everywhere the same (the heat-producing pressure being everywhere equal), the *increase* of temperature from the surface must be less at the poles than at the equator. This, however, evidently can hold good only down to a certain depth, after which the increase of temperature towards the centre is less in an equatoreal section than in higher latitudes. There exists, then, in the body of the Sun a spheroidal surface, flattened in the direction of the line of poles, over which the rate of increase of temperature towards the centre is a maximum. Now it will be in the neighbourhood of this surface that the disturbances above mentioned will of preference arise. From latitude 0° to latitude 40°, for instance, the superincumbent layers to be overcome will be less high, and the decrease of temperature outwards more marked. Accordingly, the prominences, metallic and other, as well as the spots to which they give rise, will appear there in much greater abundance. Nearer to the poles no metallic eruptions can take place, though hydrogen flames may occasionally be seen. At the equator itself fewer disturbances are witnessed; owing probably to the fact that as they originate on the spheroid at comparatively small distances from the surface, the pressure is insufficient to propel them with the requisite velocity.

The periodicity of the spots must be ascribed to a periodical development of heat, which itself may be due to various causes, as, for example, to an oscillation of the volume of the Sun about a mean position during the successive stages of its condensation. Whatever be the reason of the period, the resulting heat-wave will first reach the spheroidal surface described above in the neighbourhood of its axis, and will then gradually make itself felt in lower latitudes. Consequently the spots will appear to move down from a limiting parallel to the equator.

That the rotation-period of the spots should diminish with the latitude follows from the conception of an equatoreal belt, animated with greater angular velocity than the layers below it, and thus setting the corresponding portions of the photosphere into more rapid rotation. Young's discovery that the velocity of the chromosphere is greater than that of the photosphere seems, of course, to lend colour to the hypothesis.

Further interesting details on the aspect of spots, the nature of the corona, and the connection of auroras and magnetic disturbances with the spot-period, will be found developed in the work itself.

W. J. Crofton.

Stonyhurst College.

Selenographical Notes.

Clefts North of Aristarchus.—The rugged highlands which extend for many miles north of this brilliant object and its companion Herodotus are traversed by a number of rills specially remarkable not only on account of their general parallelism and nearness to each other, but as exhibiting in many instances short and sudden changes in direction and other peculiarities only rarely met with elsewhere.

Two of the most noteworthy of these zigzag clefts will be found between Wollaston B and the imperfect ring-plain which forms part of the so-called Harbinger Mountains, marked ϵ in Neison's Map VIII. The more southerly is associated with the north-west wall of ϵ by a row of three or more deep crateriform objects which may be seen to advantage when the morning terminator lies near Wollaston B. As sunrise progresses this crater-row is observed suddenly to change its direction towards the south-east, running for some distance at the foot of the *glacis* of the north-east wall of ϵ and then, in the form of a rill, to turn abruptly towards the north-west and Wollaston B. The second cleft is in close propinquity to the first, and resembles it both as regards its minor details and its zigzag course, which is almost exactly parallel to the similar irregularities of its neighbour. On careful examination it is clear that the extraordinary form which these rills have assumed is related to the character of the surface. In both instances their sinuosities evidently correspond with the contour of the lowest portion of a valley. At an early stage of sunrise, the coarser parts of this cleft are easily seen, in the shape of the letter "**N**" reversed, with a moderate magnifying-power. It ultimately runs northwards, parallel and in close proximity to the first, but separated from it by a prominent ridge. Schmidt is the only selenographer who shows these curious objects, but his drawing is on too small a scale to exhibit them as they appear under favourable conditions with a high power. It is worthy of remark that this neighbourhood affords, in the clefts in question and in the well-known winding valley by Herodotus, the most notable instances of the zigzag form of rill on the Moon's visible surface. In almost all other districts, whether mountainous or not, the clefts, though often irregular in width and, when critically examined, far from displaying that uniformity and directness which is usually stated to be peculiarly characteristic of them, never exhibit those sudden changes of direction which is so apparent hereabouts. At 9^h on 14th May, 1886, when the morning terminator lay a little east of the Harbinger Mountains, I detected a short rill running in a north-west direction from the western extremity of the N-shaped fissure just referred to up to the flank of the row of mountains which apparently forms a northerly prolongation of the western side of the ring-plane *ε*. When the morning terminator is a few miles east of Wollaston C, a fine view is obtained of a prominent crater-row which runs in a south-west direction from a point near C towards the ring *ε*, and of a long slightly curved coarse rill or shallow valley which originates some distance south-east of Mairan and trends towards Wollaston.

At this phase also the remarkable straight ridge associated with the crater C is a prominent feature on the terminator.

Thomas Gwyn Elger.

Kempston, Beds, July 20, 1887.

Meteor Notes.

Observations were continued on June 26, 28, and 30, when 27 meteors were recorded in 6 hours of watching. The month proved one of the clearest and most favourable I have ever known for this branch of work, though the preceding month (May) was one of the most cloudy within experience. In addition to the showers mentioned in our notes for last month, the following positions were determined from a careful comparison of the paths:—

No.	Radiant.		Notes.
	°	°	
9....	40	+56	Swift; bright streaks. *Perseids.*
10....	213	+53	Swift; bright. *Max. June 26.*
11....	238	+47	Slow, small, and faint.
12....	252	+11	Slow. Near *χ Ophiuchi.*
13....	290	+27	Rather slow. *At β Cygni.*
14....	354	+39	Very swift; streaks. *Max. June 26.*

The first of these, near *η* Persei, is new for the epoch, and the position nearly agrees with the great Perseid radiant on Aug. 10. There are many additional showers here in the summer and autumnal months, for amongst my previous observations I find the following radiants, which are well confirmed by some other determinations, which I also quote:—

Observed at Bristol.			Other observers.		
Epoch.	Radiant.		Radiant.		Epoch.
	°	°	°	°	
1878, July 26–31 ...	43	+58			
1879, Aug. 20	40	+59	42 42	+62 +55	Aug. 13–Sept. 30 (Heis). Sept. 5, 1870 (Tupman).
1885, Oct. 6–16 ...	42	+55	47	+56	Oct. 3–Nov. 14 (Heis).
1877, Oct. 8–14 ...	43	+58			
1879, Oct. 14	48	+60			
1877, Nov. 4–7......	45	+60	40	+60	Nov. 13, 1868 (S. & Z.).
1885, Dec. 1–10 ...	44	+55	45	+56	Nov. 23–Dec. 18 (G. & H.).

I have also seen traces of showers from nearly the same point at other times of the year.

One of the finest meteors recently observed here was a Perseid. Its path from 38° +48° to 39° +42½° was greatly foreshortened near the radiant, and the meteor seems to have either been slightly deflected or to have been registered with no great accuracy; but the recorded track, prolonged backwards, passes within 2° of the radiant at 40° +56°. The meteor was quite equal to ♃, and appeared at $12^{h}\ 54^{m}$ on June 25. It moved slowly, and left a short bright streak for 5 seconds.

In June I saw three bright stationary meteors, as follows:—17th at 316° −6°, 21st at 270° +47°, and 26th at 213° +53°.

Fireball.—Before sunset on the evening of June 17, when the sky was magnificently clear, a bolide of considerable magnitude was seen from several departments in the north of France, and another was observed on the 19th by Mr. H. King, of Chethurst, in Sussex. The latter, writing to 'Nature' of June 30, says:—"At about 7.45 P.M. on June 19 a brilliant meteor was seen in broad daylight from this place. At a rough estimate, it followed the meridian of Arcturus for about 30°, and disappeared near the position of that star." In 'L'Astronomie' for July it is stated the fireball of June 17 traversed the sky over the departments of the Seine, Seine-et-Oise, and the Loire. As seen at Paris it was in the form of a luminous globe about one tenth the diameter of the Moon, and was followed by a white train. The direction was from N.N.E. to S.S.W., and much inclined to the horizon. It was so large and apparently so near, that many persons supposed the meteor had fallen but a few kilometres from them. At the observatory of Juvisy its diameter was estimated as one fifth that of the Moon; and it moved slowly from angular elevations of 45° to 25°, and with a direction from N.N.E. to S.S.W. At Reuilly (Indre) the meteor was seen when 30° above the horizon, falling vertically towards the Earth in a N. direction, and emitting a red light. Here it appeared to be twenty times as bright as Venus; and some minutes after the explosion there were two loud detonations. At Orleans the brightness of the meteor was compared to that of the full Moon, and it left a long luminous train. Near Issoudan the trail endured for more than ten minutes, and this effect was probably caused by the sunlight illuminating the vapours evolved from the bolide as it exploded.

Another fine meteor was observed at a later hour on the same night. A writer at Lyons says—"On June 17, at 9^h 16^m, a magnificent bolide traversed the atmosphere, appearing between α and β, and directed towards γ, of the constellation Andromeda, finally dying out near α Persei. The meteor was as bright as Jupiter, of a yellow colour, and its duration was 4 seconds.

W. F. Denning.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Proposed Index to Observations of Variable Stars.

Gentlemen,—

For the last four years the Observatory of Harvard College has published an annual statment of the number of observations made during the previous year upon each variable star. In the fifth of these publications, to be published during 1888, it is proposed to give a statement of the number of dates of observation of each variable star during each year since its discovery. It is hoped thatan index of this kind will be useful to astronomers, even if it cannot be made complete; but its value will certainly be much increased by the addition of every extensive list of observations which can be obtained for insertion in it. All who are interested in this department of astronomy are therefore requested to send to this Observatory any information of the kind above described which they may have at command. It is very desirable that the information should be received early in 1888, in order that the publication may not be unduly delayed. Edward C. Pickering.

Harvard College Observatory,
Cambridge, U.S., June 22, 1887.

Achernar.

Gentlemen,—

I do not quite understand the intended drift of Mr. A. S. Williams's letter respecting this star. Of course I have never seen it, never having been further south from England than Switzerland; and my statement of its being "red" being given in inverted commas shows that I am quoting somebody else. That somebody else being Engelmann, I conceived that I was quite justified in inserting the star in a "Working" List, and I am not disposed to erase it without clearer proof of error on the part of Engelmann than is at present before me. Your obedient Servant,

G. F. Chambers.

Northfield Observatory, Eastbourne,
Sussex, July 7, 1887.

Observing-weather during Transit of Venus.

GENTLEMEN,—

Being desirous of forming a list of places where the transit of 1882 was observed, I lately forwarded circulars to Fellows of the R.A.S., omitting known cases, such as London. Answers have been received from 85 Fellows. The result is—56 entire failures from clouds: in 29 cases some sort of observation obtained, but at Kew, Oxford, and Llanerchymedd (Anglesea) only a glimpse for a few seconds. The state of the sky at the time of the transit was totally different at places so near as Edinburgh and Glasgow, Leamington and Worcester, Taunton and Bridport. The only place in the eastern counties where I have heard of any sight of the transit was Norwich; and it may be remarked that the only part of the country where observations were indifferent in 1769 was a portion of the eastern counties. There seems to have been a large tract of country from Worcestershire up to Cumberland (where some very rough observations were obtained) in which not a glimpse of the transit could be got. I have also ascertained that clouds prevailed entirely at Hoole (Horrox's place). The most favourable localities in England were the coast of Dorset and the south coasts of Devon and Cornwall. The South-Wales coast might also be added. The only places where the times of contacts were communicated to me were Torridon, Auchnasheen; Castle Wemyss; Dunecht in Scotland; Street, co. Westmeath; and Dover.

	Ext. cont.	Int. cont.
	h m s	h m s
Torridon	1 58 40	2 17 35
Castle Wemyss	2 6 38	2 20 32
Dunecht........ ..	1 52 49	2 10 18
Street............	1 31 54	1 52 14
Dover...........	......	2 21 20

Observations were stated to have been obtained at Newquay, Cornwall; Cheltenham; Shaftesbury, Dorset; Plymouth; Poyntington, Sherborne, Dorset; Portsmouth; Brighton; Stroud; Parsontown, Ireland; Sidmouth; East Tisted, Hants; Paisley; Cardiff (rough wind); Sillerton, Winchester (boiling); Ballysodare, co. Sligo; Bristol; Barmouth (no trace of atmosphere, but Venus brighter at the centre than at the circumference).

Faithfully yours,
S. J. JOHNSON.

Melplash Vicarage, Dorset,
June 23, 1887.

Remarks on the 'Canon der Finsternisse.'

GENTLEMEN,—

The publication of Oppolzer's 'Canon der Finsternisse' indicates a vast improvement in long lists of eclipses on any previous work of the kind. Probably the Ephemerides of Regiomontanus is the oldest book of this sort. It gives lists and diagrams of eclipses, also planetary positions from the year 1474 to the year 1506. This was followed by the catalogues of Stadius, also by 'Lanii Calendarium Romanum' a little later. The most complete list of eclipses of the 16th century, however, was that of Leovitius, the times being calculated to seconds in this case. It reached from 1554 to 1606, thus including the eclipse of 1560, total in Spain (a partial phase of which set Tycho Brahé thinking on celestial matters), also the total ones of 1598 and 1605. In the last century there was 'L'Art de vérifier les dates,' published by some French Jesuits, giving lunar eclipses to the hour only and very rough tracks of solar ones, stated in figures, between the years B.C. 1000 and A.D. 2000. We have now in Oppolzer's great work a list of the Moon's eclipses, with magnitudes approximately calculated from B.C. 1207 to A.D. 2162, and the tracks of central eclipses of the Sun mapped out, except those in southern latitudes. This laborious work may therefore be said to embrace all historic time. As a work of reference it will be invaluable for astronomers. It must, however, be remembered that the tracks of the solar eclipses are but approximate; for instance, that of 1715 is made to run far north of London; that of 1724, observed total near Salisbury, to escape England altogether; that of 1652, observed total at Edinburgh, is made to pass at sea north of Scotland; that of 1654, observed as an eclipse of five sixths of the solar diameter at London, is put total across Great Britain. Still the value of such a work must be very great. It may be remarked that, from the Christian era to the present date, 27 total solar eclipses are marked to cross some part of Great Britain, and 22 annular ones; and from the present date to the year 2162 seven total eclipses and one annular eclipse (that of 2093), according to Oppolzer, cross our isles.

Faithfully yours,
S. J. JOHNSON.

Melplash Vicarage, Dorset,
July 14, 1887.

Noises accompanying Auroræ.

GENTLEMEN,—

I read with much interest an article in the April number of the 'Observatory' on the Aurora by Mr. Henry J. Webber, in which he mentions a brilliant display seen by him in Canada which was accompanied by a sharp crackling sound. I have much pleasure in bearing testimony to the truth of his statement, having heard similar sounds in a display I witnessed in lat. 59° 23′ N. and long. 2° 52′ W.

Yours faithfully,
R. RENDALL,
Master R.M.S. 'Courland.'

June 22, 1887.

NOTES.

The Continental Observatories.—The following brief notes have been compiled from the Annual Reports of the various Observatories for the year 1886, published in the 'Vierteljahrsschrift der Astron. Gesellschaft,' 1887, Heft ii.

Berlin.—At this observatory, which is under the direction of Herr W. Foerster, the usual work with the transit-circle has been maintained, Dr. Küstner, the observer, choosing stars from Argelander and the Pulkowa list, as also stars which have been occulted by the Moon or have been observed with planets. Observations have also been made to determine the influence of brightness of the stars on the time of transit. Dr. Küstner finds that he observes faint stars later than bright ones by about $0^s{\cdot}003$ per magnitude. This quantity is liable to increase from badness of image, as, for instance, when approaching the horizon. More observations are required to obtain satisfactory results. The 9-inch equatoreal has been employed by Dr. Knorre to obtain positions of small planets, comets, and comparison stars.

Bonn.—The chief work is the revision of the Bonn Catalogues. This in itself is an immense labour. The catalogue will be for the epoch 1875·0, and one volume will be devoted to each hour of R.A. In this will be given for each star the catalogue number, the reference number in the 'Bonner Durchmusterung,' the individual observations in order of time, the date, magnitude, R.A., Dec., and the precession and secular variation for both elements. Some observations of variable stars have been made by Prof. Schönfeld.

Brussels.—The staff of this observatory are engaged on the completion of a catalogue of 10,798 stars observed by Quetelet. An early publication is promised. MM. Neisten and Stuyvaert have made some measures of double stars, and obtained positions of comets Encke and 1886 I., II., and III. Fundamental stars have been observed with the transit-instrument for the time-service. Physical observations have been made of the Moon, Jupiter, Saturn, and Venus. M. Fievez has continued the study of the solar spectrum in relation to spectra of terrestrial elements. Numerous papers have been published by the members of the observatory.

Düsseldorf.—Herr R. Luther has obtained a large number of positions of minor planets. Much time is devoted to the computation of ephemerides.

Dresden.—The private observatory of Baron von Engelhardt. With the 12-inch refractor positions have been obtained for comets 1885 (Brooks 2), 1886 (Brooks 1), 1886 (Brooks 2), 1886 (Fabry), 1886 (Finlay), 1886 (Barnard), 1886 (Barnard-Hartwig). At the instance of O. Struve, Baron Engelhardt has undertaken to make micrometric measures of all stars in Bradley and Argelander which have an annual proper motion of at least $0''{\cdot}1$, with companions not below the 10th mag., and whose distance does not exceed 3. Observations of double stars have also been secured.

Geneva.—In addition to the usual work in connection with the rating of chronometers and watches, the Plantamour equatoreal has been utilized for observations of comets and for physical observations of nebulæ and planets. The difference of longitude between Vienna and Geneva has been determined by M. Gautier, the Director, and the late Herr T. Oppolzer. The result, which is considered good, gives a mean value of $40^m\ 44^s{\cdot}64$.

Gotha.—Observations of zone stars (25°–20°), comets, and variable stars have been made at this observatory.

Herény (Hungary).—At the observatory of M. Eugen v. Gothard spectroscopic observations of comets Fabry, Barnard 1, and Barnard-Hartwig were secured. Drawings were made of Jupiter, Saturn, and Mars. The chief work has, however, been on celestial photography. Photographs of numerous star-clusters, planets, Comet Barnard-Hartwig, and the spectra of α Lyræ, α Aquilæ, α Aurigæ, β Cassiopeiæ, γ Cassiopeiæ, &c., have been obtained.

Kiel.—Much time has been devoted to computations for the Zone Catalogue of the 'Astronomische Gesellschaft.'

Leipzig.—At Dr. R. Engelmann's observatory measures of double stars and small stars in the Andromeda nebula were secured. Some spectroscopic observations were made.

Lund.—Dr. Dunér has continued his observations of variable stars and spectra of red stars. With the refractor observations have been made of planets and comets.

Milan.—Prof. Schiaparelli has had a new 18-inch refractor mounted recently, but has not had time to do any work with it. With the 8-inch refractor observations of comets 1885 V., 1886 I., II., III., V., VII., and IX. have been made.

Munich.—The ordinary zone work has been continued with the transit-circle. With the refractor positions of comets have been secured, and some time has been spent in photometric researches.

O'Gyalla.—Under Dr. Konkoly the staff of this observatory have been engaged in observations of sun-spots and comets. The spectra of Jupiter, Saturn, and Mars have been compared with the sun-spectrum. Much attention has been given to stars with variable spectra. Observations of stars for the spectroscopic Durchmusterung have been continued (zone 0° to −15° S.); the results will be published in a catalogue, already in type. The usual meteorological observations have been carried on.

Palermo.—The work here consists of observations of comets, small planets, occultations of stars by the Moon, sun-spots, and physical observations of the Moon's surface. It is also a meteorological observatory.

Potsdam.—The spectra of prominences and sun-spots have been observed during the year, and physical observations of Jupiter and Mars have been made. Dr. Müller has been engaged in photometric work on all the large planets, as well as on Flora, Vesta, [illegible] and [illegible]. Comets Fabry and Barnard were observed photometrically as was also the variable near χ¹ Orionis. A series of measures for difference of brightness between the Sun and Moon have been made. Work on stars for the spectroscopic Durchmusterung has been done (zone [illegible] to —23°). Dr. Lohse has been employed in photography. Photographs of the Andromeda nebula, the ring-nebula in Lyra, &c., have been taken.

[illegible] Dr. [illegible].—Numerous observations of variable stars have been made.

The Almucantar[*].—In this paper Mr. S. C. Chandler publishes the results of an investigation made by him at the Harvard College Observatory in 1884 and 1885 in order to test the efficiency of the peculiar form of zenith telescope devised by him, and which he has called the Almucantar. This instrument, as our readers will remember, consists of a telescope mounted upon a base that floats in mercury; the observation consisting in noting the time of transit of a star across an almucantaral (or horizontal) circle in which the telescope revolves. The particular horizontal circle which Mr. Chandler has found most convenient is that passing through the pole, which he calls the "Co-latitude" Circle. Between the successive pointings of the telescope oscillations are of course set up in the mercury and float, but these subside completely in a couple of minutes, and a mean position of equilibrium is regained within a range of variation so minute that no means exist of certainly measuring it. Mr. Chandler thinks he is entitled to hold, as a fair conclusion from his investigation, that the Almucantar compares favourably with the meridian circle for such purposes as time or latitude determinations, and certainly in his hands and in those of such a skilful observer as Prof. Rogers (who took part in the observations discussed by Mr. Chandler) it appears to do so. It remains to be seen, however, whether in less skilful hands as satisfactory results could be obtained with the new as with the older form of instrument.

The Total Solar Eclipse of 1886[†].—Mr. W. H. Pickering, who was stationed at Grenada, gives a brief account of the more striking phenomena recorded on the photographic plates exposed by him during the total eclipse of last August. By using rapid gelatine plates it was found that an exposure of one or two seconds was sufficient to show the details of the inner corona with an ordinary telescope-lens. With a portrait-lens, the ratio of whose aperture to its focus was as one to five, one or two seconds exposure showed the outer corona satisfactorily, as far as a distance of from 15′ to 30′ from the limb of the Moon. The corona showed the usual short rays proceeding from the Sun's poles, and from the S.W. quadrant a very conspicuous ray, appearing like a hollow cone, projected to a distance of about 20′. A number of prominences were seen near the Equator, on both sides of the Moon, but the most conspicuous one was situated in the N.W. quadrant. It extended to a height of about 100,000 miles, and had apparently a somewhat spiral structure.

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[*] Annals of the Astronomical Observatory of Harvard College, Vol. xvii.

[†] Science, Vol. x. No. 230.

The spectra of the various prominences were shown very clearly by the prismatic camera. In the equatoreal ones the hydrogen and H and K lines were conspicuous, but in the large prominence the hydrogen lines were all absent, although the H and K lines were strongly marked. The position of the maximum density in the continuous spectrum of the prominences was found to be quite different from that of the corona. In the former it is found to be not far from the G line, whilst in the latter it lies between G and F. Photometric measurements of the general light during totality were made, which, roughly stated, indicate a brightness equal to one candle at about 29 inches distance.

The Parallax of α Tauri[*].—M. O. Struve has recently published ('Monthly Notices,' vol. xliv. p. 237) a determination of the parallax of this star derived from measures of its position-angle and distance referred to the 11th magnitude companion. He found the mean annual parallax $\pi = +0''\cdot516 \pm 0''\cdot57$. Prof. Asaph Hall now publishes the results of a series of measures of the relative positions of the same stars, made with the Washington refractor between October 2, 1886, and March 15, 1887. His results are:—position-angle $\pi = +0''\cdot163 \pm 0''\cdot0409$, and distance $\pi = +0''\cdot035 \pm 0''\cdot0431$. The mean value is therefore $\pi = +0''\cdot102 \pm 0''\cdot0296$. On a previous occasion Prof. Hall pointed out that, generally, his observations for stellar parallax give results that are smaller than those found by other observers ('Observatory,' vol. i. p. 142).

The Oxford University Observatory.—The twelfth Annual Report of the Savilian Professor of Astronomy to the Board of Visitors of the University Observatory was read on June 8, 1887. Prof. Pritchard states that portions of both the equatoreal instruments have been placed in the hands of the opticians, with a view to modifications or repairs which shall render them applicable to the entirely new departure which is now in progress in respect of the processes and methods of practical astronomy. To enable the University Observatory to carry out certain experimental investigations required by the Photographic Committee of the Royal Society with regard to the limits of accurate field obtainable from mirrors of different focal lengths, Dr. De La Rue has supplied two mirrors of 15 inches aperture of different focal length, and these are to be mounted alternately on the tube of the refractor, together with a camera as arranged by Mr. Grubb. The attempt to obtain, for the first time in the history of astronomy, the distance of the fixed stars by the aid of photography has, Prof. Pritchard considers, been attended with success in the case of 61 Cygni. The first observation was obtained on May 26 of last year, and the last on May 31 of the present year. The reductions involved 30,000 bisections of star-images on 330 photographic plates procured on 89 nights. Similar work has been in progress for the determination of the parallax of μ Cassiopeiæ and Polaris. Photographic plates of the Pleiades have also been taken with the view of obtaining accurate relative positions of about 100 stars of the group.

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[*] 'The Astronomical Journal,' No. 156.

VARIATIONS IN THE SUN'S DIAMETER[*].—This paper by Herr Auwers is a continuation of his researches on the Sun's diameter, the first part of which was published in the No. of the 'Sitzungsberichte' for December 2, 1886 ('Observatory,' Vol. x. p. 173), and discusses the apparent changes of both the horizontal and vertical diameter during the course of a year deduced from meridian observations. After referring to the periodic changes in the monthly values of the Sun's diameter which have been deduced from Greenwich, Milan, Madras, Washington, and Neuchâtel observations by different investigators, Herr Auwers gives the results of his own researches on the subject, which include an elaborate discussion of the observations with the Greenwich Transit-Circle 1851–1883, the Washington observations 1866–1882, and the Oxford (Radcliffe) observations 1863–1876, exhibiting for each series (corrected for personality by the methods explained in the former paper) the discordances both of horizontal and vertical diameter for each month from the general mean.

The following are the mean results for Greenwich :—

Month.	Discordance.	Month.	Discordance.
January	−0″·36	July	+0″·08
February	−0·24	August	+0·01
March	−0·03	September	−0·06
April............	+0·22	October	−0·10
May	+0·25	November	−0·22
June	+0·08	December	−0·35

Herr Auwers concludes that these variations result not from physical changes in the Sun, but from the effect of temperature on the instruments, and from difference in the quality of the telescopic images at opposite seasons of the year.

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[*] 'Sitzungsberichte der königlich Preussischen Akademie der Wissenschaften zu Berlin,' No. xxviii. June 9, 1887.

ERRATUM IN No. 125.

Page 263, line 7 from foot, *for* 40 *read* 25·40.

o. 127.] SEPTEMBER, 1887. [*Price* 1s.

THE OBSERVATORY,

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EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

Articles:—

PAGE
Theodor von Oppolzer 309
Meteor Notes. By W. F. Denning, F.R.A.S. 313
Selenographical Notes. By Thos. Gwyn Elger, F.R.A.S. 316

Correspondence:—

Suggested Mean Distances of Ultra-Neptunian Planets. By W. T. Lynn, F.R.A.S. 318
The Comet of 1680 and its supposed previous appearances. By W. T. Lynn, F.R.A.S. 318
The Variable Star Algol. By J. M. Barr 320
The Periods of the Planets. By W. H. S. Monck, M.A., F.R.A.S. 322
The Orbits of Comets. By W. H. S. Monck, M.A., F.R.A.S. 324
Colour of eclipsed Moon 3rd August. By the Rev. S. J. Johnson, F.R.A.S. 325
Method of regulating Clocks. By W. H. M. Christie, M.A., F.R.S. 326

Notes:—

The Total Solar Eclipse of August 19.—Flamsteed's Stars "Observed but not Existing."—Corrigenda in various Star Catalogues.—Tomlinson's "Pneumatics."—The Meudon Observatory.—Magnitudes of Stars employed in Nautical Almanacs.—Break-circuit Chronometers.—Achernar.—Partial Lunar Eclipse of Aug. 3, 1887.—New Variable Star in the Ring Nebula in Lyra.—The Algol-type Variable, Y Cygni.—New Variable Star.—Discovery of a Comet.—The late Mr. Alvan Clark.—Editorial Notes 326–336

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CONTENTS OF No. 126.

Pa

Annual Meeting of the Liverpool Astronomical Society 28

Articles:—

The Applications of Photography in Astronomy. By David Gill, LL.D., F.R.S., &c. 287
Observations of Comet 1886 *e* (Finlay). By H. C. Russell, B.A., F.R.S. ... 29
Braun's Theory of the Sun. By the Rev. W. J. Crofton 29
Selenographical Notes. By T. G. Elger, F.R.A.S. 29
Meteor Notes. By W. F. Denning, F.R.A.S. 29

Correspondence:—

Proposed Index to Observations of Variable Stars. By Edward C. Pickering, For. Assoc. R.A.S. 301
Achernar. By G. F. Chambers, F.R.A.S. 301
Observing-weather during Transit of Venus. By the Rev. S. J. Johnson, F.R.A.S. 302
Remarks on the 'Canon der Finsternisse.' By the Rev. S. J. Johnson, F.R.A.S. 302
Noises accompanying Auroræ. By R. Rendall 303

Notes:—

The Continental Observatories.—The Almucantar.—The Total Solar Eclipse of 1886.—The Parallax of α Tauri.—The Oxford University Observatory.—Variations in the Sun's Diameter........ 304-308

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 127. SEPTEMBER. 1887.

Theodor von Oppolzer *.

THEODOR V. OPPOLZER was born at Prague on October 26, 1841, and had only attained the age of 45 years at his death. We may well be astonished at the vast amount of work which he completed in his short life. Striding forward from achievement to achievement in a continual course of victory, he had already become known in his youth, placing his name with equal distinction by that of his great father, and whilst in the full vigour of physical health and intellectual capacity he was suddenly snatched from us on the day after Christmas last year, and we perforce recall the words on the tomb of the immortal Galileo—"Much has he given us, more has he taken with him."

Johann v. Oppolzer, the never-to-be-forgotten Master of our Medical School, wished to devote his son to the medical profession; but his private tutor, whose name deserves thankful mention here (the late Herr Franz Jahne, formerly superintendent of Highroads), perceived the dominant inclination of the boy for mathematical studies and knew how to promote them. Whilst the father with never-surpassed acuteness detects the symptoms of disease in the microcosm of the human eye, the son turns his gaze to the macrocosm of the starry universe with that silent and deep enthusiasm before which all difficulties vanish; and in his twentieth year, Theodor v. Oppolzer, just commencing his medical studies, has already in 1861 published his first contribution to Astronomy—'Ueber die Bahn des Kometen I, 1861.'

In January 1865 he graduates as Doctor of Medicine at the Vienna University, and the young man, now twenty-four years of age, has already published fifty-six different orbits of small planets, ephemerides, and other astronomical works. In the following year he is Privat-docent for theoretical astronomy; in 1869, when 28 years of age, he is a corresponding member of the Imperial Academy; when 29 he publishes the first volume of his classical work, 'Lehrbuches zur Bahnbestimmung der Kometen und Planeten,' a work since translated into the French language, and of which a new edition has been recently issued; and in the same year he was appointed Extraordinary Professor of Astronomy and higher Geodesy at the Vienna University.

---

* Translation of an obituary discourse delivered at the Annual Meeting of the Imperial Academy of Sciences of Vienna.

Two years later, in the year 1872, the Government sends the young astronomer, whose renown was increasing so rapidly, as Austrian representative at the International European Geodetic Congress, which was instituted for inquiry into the true figure of the Earth; and now a new and wide field for work opens to him. Earlier in the century it would have been scarcely thought possible that, whilst part of the world bristled with arms and the trembling millions expected from day to day the outbreak of the most fearful war, at the very same time, as if in a higher sphere, the representatives of all nations should gather together again and again in a noble emulation to promote the extension of human knowledge. There they measure or span in their computation the great globe itself; into these regions the conflict of interests does not reach, and here at least it is as it ought to be, the dream of a world-peace takes form and reality.

In the meantime the private observatory directed by Oppolzer in the Alserstrasse, Vienna, enriched science with an unbroken series of new observations and positions, and Oppolzer applied himself closely to two great undertakings—the motion of the Moon and the inquiry into Eclipses. In the year 1881 he published his 'Syzygien-Tafeln für den Mond,' and in the year 1882 the Imperial Academy elected him full member. In the year 1883 he presented to the same body his 'Tafeln für die Berechnung der Mondesfinsternisse;' and in the year 1885, in which the Government sent him to the International Conference on Weights and Measures, his work of many years, the 'Canon der Finsternisse,' was finished.

This work has already been designated at the last session of the Imperial Academy as one of the greatest works of calculation which has ever been accomplished by man. It embraces the computation of every eclipse for a period of 33 centuries, from B.C. 1203 to A.D. 2163, and includes 8000 solar and 5200 lunar eclipses. For some years a band of skilled workers, part volunteers and part paid out of his private means, supported him in his calculations, the original manuscripts of which, according to the report of his faithful coadjutor Dr. Schram, filled 242 large folio volumes, with more than 10 million figures. The results fill the 52nd volume of our Memoirs.

Of this memorial which he thus erected for himself he did not see the completion. When the last proof-sheet was thrown off, he already lay on his death-bed.

The history of the Vienna University notices with pride how, more than four centuries ago, under Georg von Peurbach, astronomical studies sprang up at the High School. Peurbach also computed tables of eclipses which did not, it is true, reach the printer until long after his death. He also died young, in 1461, when only 38 years old. But so deep and lasting was Peurbach's influence as a teacher, that the self-composed epitaph of his renowned pupil, Regiomontanus, at Nürnberg, praises the beloved Vienna Teacher, as if Regiomontanus wished to carry his gratitude over the borders of life. And just as deep a feeling of love and gratitude has Oppolzer left behind in the hearts of his pupils and friends. These feelings flow from two sources, from the elevated nature of that science in which he had conducted his pupils, and from his personal singleheartedness. Then no one of us has ever seen Oppolzer other than bright, with that cheerful openness which invited intercourse and agreeably won regard, and which is the never-failing outward expression and consequence of a pure and truly noble soul-life.

Two years ago Oppolzer had undertaken a task which is most closely connected with his Lunar Theory, published in the 51st volume of the 'Memoirs' of the mathematical and natural science section. He deals with the differential equations of the perturbed motion of the Moon which present themselves in this theory, and the numerical solution of these equations so far that the integration is reduced simply to a question of quadratures. The completion of the work, which has been interrupted by his death, has been secured through the care of his widow, Frau Coelestine v. Oppolzer, *née* v. Mauthner, by the skill and under the direction of Herr Dr. Schram. This work will appear on its completion in the 'Memoirs' of the Imperial Academy.

Scientific Works.

The following list is derived from a complete catalogue drawn up by Dr. Robert Schram of the published writings of Th. v. Oppolzer, which comprises 318 numbers, and which will appear in the 'Vierteljahresschrift der astronomischen Gesellschaft':—

Bahnbestimmung des Planeten (64). Sitzb. Wien. Bd. xlvii. S. 229–241.

Entwicklung von Differentialformeln zur Verbesserung einer Planeten- oder Kometenbahn nach geocentrischen Orten. Sitzb. Wien. Bd. xlix. S. 271–288.

Die Constanten der Präcession nach Le Verrier. Sitzb. Wien. Bd. lvi. S. 579–593.

Definitive Bahnbestimmung des Planeten (58) "Concordia." Sitzb. Wien. Bd. lvii. S. 343–383.

Ueber die Bestimmung einer Kometenbahn. II. Abh. Sitzb. Wien. Bd. lx. S. 918–944.

Lehrbuch zur Bahnbestimmung der Kometen und Planeten. I. Band. Leipzig, 1870. W. Engelmann. 353 Seiten.

Ueber den Venusdurchgang des Jahres 1874. Sitzb. Wien. Bd. lxi. S. 515–599.

Ueber den Winnecke'schen Kometen (Komet III. 1819). I. Abh. Sitz. Wien. Bd. lxii. S. 655–675.

Ueber den Winnecke'schen Kometen (Komet III. 1819.) Sitzb. Wien. Bd. lxviii. S. 237–292.

Das Schaltbrett der österreichischen Gradmessung. Sitzb. Wien. Bd. lxix. S. 379–398.

Ueber einige Relationen zwischen den Combinationssummen der Quadrate der geraden und ungeraden Zahlen. Mathematische Annalen, Bd. xiii. S. 405–410.

Neue Methode zur Bestimmung der Bahnelemente gleicher Wahrscheinlichkeit für einen kleinen Planeten. Monatsb. Berlin, 1878, S. 581–602.

Entwicklung der Differentialquotienten der wahren Anomalie und des Radiusvector nach der Excentricität in nahezu parabolischen Bahnen. Monatsb. Berlin, 1878, S. 582–859.

Lehrbuch zur Bahnbestimmung der Kometen und Planeten. II. Bd. Leipzig, 1880. 635 Seiten.

Ueber die Berechnung der wahren Anomalie in nahezu parabolischen Bahnen. Abh. der II. Cl. der k. Akad. d. Wiss. in München. Bd. xiii. Abh. iii. S. 137–168.

Ueber die Bestimmung grosser wahrer Anomalien in parabolischen Bahnen. Monatsb. Berlin, 1880, S. 511–515.

Syzygien-Tafeln für den Mond. Publication der astronomischen Gesellschaft. XVI. Leipzig, 1881. W. Engelmann. 48 und [54] Seiten.

Lehrbuch zur Bahnbestimmung der Kometen und Planeten. I. Bd. Zweite völlig umgearbeitete Auflage. Leipzig, 1882. W. Engelmann. 684 Seiten.

Beitrag zur Ermittlung der Reduction auf den unendlich kleinen Schwingungsbogen. Sitzb. Wien. Bd. lxxxvi. S. 713–732.

Ermittlung der Störungswerthe in den Coordinaten durch die Variation entsprechend gewählter Constanten. Denkschr. Wien. Bd. xlvi. S. 45–75.

Ueber die Kriterien des Vorhandenseins dreier Lösungen bei dem Kometenprobleme. Sitzb. Wien. Bd. lxxxvi. S. 885–892.

Tafeln für den Planeten (58) "Concordia." Denkschr. Wien. Bd. xlvii. S. 149–159.

Tafeln zur Berechnung der Mondesfinsternisse. Denkschr. Wien. Bd. xlvii. S. 243–275.

Bericht über die Bestimmung der Schwere mit Hilfe verschiedener Apparate. Annex VI. *a* zu den Verh. der 1883 in Rom abgehaltenen VII. allg. Conferenz der europ. Gradmessung, pag. 1 bis 28; derselbe französisch ebendaselbst Annex VI. *b*, pag. 38–64 (der deutsche Bericht abgedruckt in d. Zeitschr. für Instrumentenkunde IV. Jahrg. Sept., S. 303–316, und Nov., S. 379–387).

Ueber die Länge des Siriusjahres und der Sothisperiode. Sitzb. Wien. Bd. xc. S. 557–584. (Auszug aus d. Akad. Anzeiger Nr. xxiii. in d. Astr. Nachr. Bd. 110, Nr. 2633, S. 271–272.)

Ueber Weltzeit. Vortrag gehalten im Vereine zur Verbreitung

naturwissenschaftlicher Kenntnisse am 8 April, 1885. Ver. nat. K. Bd. 25, S. 415–440.

Ueber die Auflösung des Kepler'schen Problems. Denkschr. Wien. Bd. L. S. 185–243. (Auszug aus d. Akad. Anzeiger Nr. ix. in d. Astr. Nachr. Bd. 112, Nr. 2672, S. 127–128.)

Canon der Finsternisse. Denkschr. Wien. Bd. lii., Wien 1887. xxvi und 377 Seiten und 160 Karten.

Entwurf einer Mondtheorie. Denkschr. Wien. Bd. li. S. 69 bis 105.

Ueber einen Apparat zur absoluten Bestimmung der Schwingungszahl einer Stimmgabel. Akad. Anzeiger Wien 1886, Nr. x. S. 82–85.

Ueber die astronomische Refraction. Denkschr. Wien. Bd. liii. S. 1–52.

Meteor Notes.

The very clear weather in June was continued in July, and between the 13th and 31st I obtained observations on 14 nights. In all 340 shooting-stars were recorded during 36¼ hours of work.

The last few nights of July constitute an important meteoric epoch; and I pointed out in 1878 ('Observatory,' Vol. ii. p. 164) that two very rich streams are visible at this period, namely from near δ Aquarii and χ Persei. I observed the July meteors in 1879, 1881, and 1883, and amply confirmed my results of 1878. This present year I counted 179 meteors on July 27, 28, 29, and 31, and of these 36 were Perseids and 27 Aquarids. I saw eight additional Aquarids on August 1, though the Moon was nearly full.

The July Perseids are simply the forerunners of the great August shower. I saw the first indication of them this year on July 18, and on July 19 registered several fine meteors from 19° +51°. On succeeding nights the displacement of the radiant towards the east became very obvious, and nearly agreed with the positions given in my paper in the 'Monthly Notices,' Vol. xlv. pp. 97, 98. From my observations of this shower during the last twenty years, it is certain that it endures from July 19 to Aug. 22 with a radiant advancing from 19° +51° to 76° +57°; and there is strong evidence it begins yet earlier, for on July 13, 1885, I noted a few streak-leaving meteors from 11° +48°, which would be the exact position of the Perseid shower on the date named.

The contemporary display near δ Aquarii attains a maximum on about July 28, and I have seen it as follows:—

1877, August 3–16....	342°	−12°	10 meteors.
1878, July 27–31	341	−13	54 „
1879, July 28	338	−14	14 „
1883, July 28	337	−11	18 „
1887, July 27–Aug. 1 .	337	−12	35 „

In 1881, July 27, I observed many meteors from Aquarius and Perseus, but did not determine their precise radiant-points. I have seen no displacement in the Aquarid centre similarly to that affecting the Perseids, and the former shower seems prolonged far into August. It was recognized here on Aug. 10–12, 1877, on Aug. 14, 1887, and on Aug. 21, 1879. I have combined the observations in the years 1877 and 1887, and find the radiants as follows:—

1877–87, August 10–14 ..	336° −11°	12 meteors.
1879, August 21	339 −10	14 ,,

Heis, from Neumayer's observations in Melbourne, found a radiant at 337° −10° for August, and from Col. Tupman's unreduced meteors I derived a position at 340° − 14° for Sept.–Oct. 4, 1869. The August and September Aquarids therefore diverge from an apparently identical position to the July Aquarids.

Of the minor showers witnessed here in July, I have selected the following:—

No.	Date, 1887.	Radiants.	Notes.	Comparisons.
1...	July 27–31	5° +10°	Swift; streaks.	7° +11°, July 31–Aug. 1, 1878.
2...	July 22–Aug. 1	16 +31	Swift; streaks.	15 +34, Aug. 8–13, 1868–69.
3...	July 20–Aug. 2	21 +57	Swift; streaks.	20 +57, July 21–Aug. 4, 1886.
4...	July 27–31	34 +18	Swift; streaks.	31 +18, July 20–31, 1878.
5...	July 21–Aug. 1	46 +26	Swift; streaks.	44 +25, Aug. 8–11.
6...	July 14–31	260 +69	Slowish.	260 +68, July 24, 1884.
7...	July 14–31	269 +49	Swift.	267 +49, July 1873. 275 +47, July 25, 1884.
8...	July 14–22	310 + 9	Swift.	314 +10, July 5–28.
9...	July 13–27	333 +12	Rather swift.	333 + 9, July 31–Aug. 2, 1878.
10...	July 16–31	335 +49	Swift; short.	332 +50, July 31–Aug. 1, 1878.

The earlier observations of Nos. 2 and 8 were by Profs. Denza and Schmidt respectively; the others by myself.

No. 5, at 46° +26°, near Musca, has never been detected before as early as July, though there can be no doubt it is associated, if not identical, with the shower of Muscids I delineated in the 'Monthly Notices,' Vol. xl. p. 130, where the position is given at 44° +25° and the max. epoch as Aug. 8–11. The stream is an interesting one; in the morning hours at the end of July and beginning of August it yields many conspicuous meteors with long paths and streaks. The shower No. 4, S.E. of α Arietis, which I saw in July 1878 and 1887 and on Aug. 10, 1877, is rather near it, and the meteors are very similar, but the two streams are quite distinct.

No. 7, at 269° +49°, near Draco's head, is an active radiant of swift meteors. It is curious that in June last I found a shower of slow, bright meteors at nearly the same point (270° +47°, 'Observatory,' July 1887, p. 265); and I have also recognized this radiant in August. These Draconids form one of our best observed displays; the mean centre from 14 radiants in July and August is at 270°·7 +48°.

No. 10, at 335° +49°, represents the Lacertids. They are small, short, uninteresting meteors. Many observers have fixed the place of the radiant, the mean of all being at 332° +49°·5 for July–August.

Several prominent systems noticed here in preceding years have given no sign of activity in this. Amongst these I may instance radiants at 6° +37°, 30° +36°, 48° +43°, and 291° +70°, which appear to have quite escaped me this year.

So many brilliant meteors have been registered since July 19 that it would be tedious to refer to them in detail; but I give a few exceptions:—On July 27, at 13^{h} 21^{m}, I saw an Aquarid = ♃, moving from 319½° +16½° to 308° +32°. On July 31, 10^{h} 40^{m}, Mr. G. T. Davis, at Theale, near Reading, observed a meteor, = ♀, with path from 2½° +17½° to 22⅓° +32°. On Aug. 1, at 12^{h} 18^{m}, I noticed a fireball many times brighter than Venus falling from 338° +43° to 164° +70°. It began like a 3rd-mag. star, and travelled some 30° without exceeding 1st mag., then it suddenly brightened, and, as it passed down the N.N.W. sky, gave a bright flash, notwithstanding the presence of the nearly full Moon. It left a train for a few seconds. This fine meteor, as well as the one described by Mr. Davis on July 31, belonged to the Aquarid shower, from which I also saw a stationary meteor on July 29 at 14^{h} 17^{m}, in the point 336° −11°. For two seconds it stood perfectly motionless, like a sparkling 2nd-mag. star. On Aug. 8, at 11^{h} 28^{m}, I noted a very fine meteor, which near the end gave a flash brighter than the moonlight, passing from 349° +15° to 9° +14¼°. Its motion was rather swift, probable radiant at 304° +11°.

Between Aug. 1 and 14 I recorded 191 meteors, of which about 71 were Perseids. On Aug. 10 I counted 22 Perseids in the 1¼ hour before 11^{h} 15^{m}, but the shower seemed rather feeble in comparison with some of its previous returns. On Aug. 11 16 Perseids were counted in 1 hour, but the sky was much involved in clouds. The shower was also continued on Aug. 14, though it only gave two meteors per hour for one observer. On Aug. 6 I noticed a very sharply defined radiant at 31° +49°, quite distinct from the Perseids, which gave a centre on the same night at 42° +55°. The former shower appears to be the same as one distinguished here in 1880, Aug. 11–13, at 30° +47°; and it may possibly have some connection with Comet I., 1870, which has a radiant at 25½° +45° Aug. 12 according to Prof. Herschel, and at 27°·9 +48°·4 Aug. 14 according to Dr. Dreyer. This comet at its descending node passed very near the Earth's orbit.

Bristol, 1887, Aug. 15. W. F. Denning.

Selenographical Notes.

Le Monnier and the Neighbourhood.—The remarkable character of the mountainous region bordering the western section of the Mare Serenitatis is seen to the best advantage under evening illumination, when the terminator has advanced as far east as 35° W. longitude. During the interval between this phase and the time when the western walls of Posidonius and Le Monnier are intersected by it, most of the striking peculiarities of the surface-structure of the "coast-line" are revealed,—especially in the vicinity of the curious bay-like inflexion of the border of the Mare, known as Le Monnier, which, being supposed to represent the remains of a partially-destroyed ring-plain, pertaining to the same type as Lee and Doppelmayer on the eastern side of the Mare Humorum, is a special object of interest to Lunar observers.

I obtained an exceptionally favourable view of this object between 13^h and 14^h, on August 8th, with a power of 284 on a 8½-in. Calver reflector, the terminator during the time of observation grazing the western flanks of Le Monnier and Posidonius. A very cursory examination suffices to show that though the first-named formation resembles Doppelmayer in lacking a definite wall on the side facing the Mare, it differs from it in exhibiting no traces of a once-existent ring. What we see in Le Monnier is a bright semi-ellipse with two obscure parallel ridges forming its minor axis, traversing the widest part of the bay, while in the other object we observe tolerably complete remains of an entire circular ring-plain. Beer and Mädler, and Neison, show a lofty isolated mountain (A, Neison's Map III.) nearly in the centre of the bay. This object is egregiously misplaced. It does not stand alone, but forms part of a short spur or hook-shaped projection from the south side of the formation and only encroaches to a slight extent on the bay opening. Opposite to it, on the north side of Le Monnier, there is a somewhat similar, but far less noteworthy, projection which extends some distance beyond the limits of the ring towards the interior. The more westerly of the two parallel ridges, just mentioned as forming an imaginary minor axis to the semi-ellipse, appears to connect these projections; while the other, apparently originating on the south at the lofty spur close to the first, runs parallel to it nearly across the mouth of the bay, but, instead of joining the low spur on the north side, trends towards the north-east and dies out on the surface of the Mare some distance east of Le Monnier. A third ridge runs out in a N.E. direction from the bright spur, A, and terminates opposite the centre of the bay. An interesting and important, though hitherto unrecorded, feature was remarked in connection with the northern side of the formation, viz. the linear extension of this flank towards the east in the form of a number of low hills and mounds, gradually decreasing in altitude and size. These somewhat obscure details represent, in my opinion, the site of a portion of the original north wall. If this be so, the formation, before its partial destruction, resembled in shape a rather elongated ellipse, crossed about midway by the meridian which marks 30° west longitude, with its major axis slightly inclined to this meridian and directed from W.S.W. to E.N.E., thus bringing it into much closer parallelism with an imaginary centre line through Posidonius and Charcornac than if the inflexion in the coast-line is regarded, as shown in the Maps, without reference to the row of objects, forming an easterly extension of the N. wall of Le Monnier, revealed under a low Sun during evening illumination.

The parallel ridges crossing the bay, reminding one of "a bar" or shoal at the mouth of a river, are prolonged in a southerly direction far beyond the limits of Le Monnier in the form of a single broad ridge, which may be traced along the border of the Mare Serenitatis up to Mt. Argæus. The many details on the floor and in the neighbourhood of Posidonius were well seen on 8th August. The fine object Daniell was intersected by the terminator at 13^h and displayed to advantage the extensive slope of its outer wall, which appears to reach nearly up to Posidonius *m*.

The brilliant crater I. on the exterior of the northern rampart of Posidonius was filled with shadow and exhibited two breaks in its western rim, presumably due to the existence of craterlets. Schmidt is the only selenographer who shows the curious "pockets" which exist in the western wall of Posidonius, viz. elongated depressions shaped something like an hour-glass or figure 8. They are very obvious at sunset. It is worth remark that these features seem, as a rule, to be more generally found in the *western* walls of large formations than elsewhere. Fracastorius, Theophilus, Cyrillus, Catherina, Cleomedes, Petavius, Purbach, and Bullialdus may be cited as striking instances of this peculiarity, which may likewise be traced in much smaller objects. The great cleft which runs from north to south on the west side of the bright crater A, on the floor of Posidonius, was hardly so easy an object as it usually is under an equal solar altitude at sunrise. The short cleft on the northern section of the interior, running at right angles to the last, was very distinct, and seems to be, as Schmidt shows it, rather a narrow valley between two parallel ranges of steep hills than a true cleft.

At the time of observation the Sun had set on the greater part of the ring-plain Charcornac, so that only a portion of the eastern side of the formation was visible, and this was, to a great extent, involved in half-shadow. There is a curious tendency to parallelism in the mountains which, running from the south-east side of Posidonius, border Charcornac on the east.

THOMAS GWYN ELGER.

Kempston, Beds, 1887, August 20.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Suggested Mean Distances of Ultra-Neptunian Planets.

GENTLEMEN,—

In the third volume of the 'Observatory,' p. 439 *et seq.*, there is an abstract of a memoir read before the Royal Society of Edinburgh by Prof. G. Forbes, in which he elaborately puts together the aphelion distances of all the comets for which elliptic orbits have been computed, with the view of ascertaining whether any indications could thence be deduced with regard to the probable distances of planets revolving round the Sun beyond the orbit of Neptune. Some of these aphelion distances are, however, necessarily very uncertain; and I do not purpose here to refer at all to the suggestions to which Prof. Forbes was led by his examination.

What I do wish to do is to call attention to two remarkable points which he has practically passed over, but may possibly be of some significance. It is known that the aphelion distance * of the comet of 1866, with which the Leonid meteors are connected, is nearly the same as the mean distance of Uranus. Now that of the third comet of 1862 (which is similarly connected with the Perseid meteors) amounts to 48·7, which is very nearly equal to the sum of the mean distances of Uranus and Neptune (19·2 + 30·1).

Prof. Forbes includes in his list the third comet of 1845, but does not refer to the fact that the elements of its orbit present a striking resemblance to those of the orbit of the comet of 1596. This, however, had been pointed out long before; and it seems very probable that these comets are identical, with a period of about 250 years. Now the aphelion distance of this comet, according to D'Arrest's elements, amounts to 79·1, which is very nearly equal to that of the comet last mentioned with the distance of Neptune added on again; the distance of Uranus + twice the distance of Neptune = 19·2 + 30·1 + 30·1 = 79·4.

Whether this points to the existence of ultra-Neptunian planets at the approximate mean distances 49 and 79, I do not wish to express any strong view, but thought it worth while, with your permission, to call attention to the distances in question.

Yours faithfully,
W. T. LYNN.

Blackheath, 1887, Aug. 1.

The Comet of 1680 *and its supposed previous appearances.*

GENTLEMEN,—

In Gibbon's famous history he mentions the great comet which appeared in the fifth year of the reign of Justinian, and which is now understood to have been, in all probability, a return of Halley's periodical comet. He then goes on to state that this comet had been "found to have revisited the Earth in seven equal revolutions of 575 years," the last being in the year 1680, and suggests that it will be observed again in 2355 [Gibbon is not very accurate in his use of the "excellent touchstone" which he somewhere calls arithmetic, and evidently means here 2255] "by the astronomers of some future capital in the Siberian or American wilderness."

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* Prof. Forbes gives this as 16·8. Using Oppolzer's elements (Astr. Nachr. vol. lxviii. p. 250), I found it to be 19·7.

The historian modestly disclaims much knowledge of astronomy, and remarks that on this point he draws his "humble science from the article 'Comète' in the French Encyclopédie by M. d'Alembert." In that place, however, the writer merely mentions the conjecture of Halley on this subject, owing to fine comets having been seen in B.C. 44, A.D. 531 and 1106, and adds that "nos descendans pourrout vérifier" whether these were successive appearances of the same comet seen again in 1680. But Halley's conjecture respecting this comet had been shown to be untenable many years before Gibbon wrote; for Dunthorne, in the 'Philosophical Transactions' for 1751 (in the same paper in which he first suggested the identity of the comets of 1264 and 1556), pointed out that the course traversed by the comet of 1106, as indicated by the accounts of its appearance, was inconsistent with its having been identical with the comet of 1680. This being so, all probability of the identity of the latter with the comets of A.D. 531 and B.C. 44 was at once taken away, long before Encke had shown by his investigations that the orbit of Newton's comet was indeed elliptical, but an ellipse which it requires a much longer period than 575 years to complete.

Although the comet of 1106, then, could not have been identical with that of 1680, it must, like the latter, have made a very near approach to the Sun. Mr. Maxwell Hall suggested several years ago in the 'Observatory' a connection between the former and the comets of 1843, 1880, and 1882. Without accepting all his suggestions respecting supposed previous appearances, it certainly seems that we have in these a family of comets moving along nearly the same orbit; and since the time when he wrote, another member has probably been added to it in the comet observed in the southern hemisphere last January. That the comet of 1106 belongs to the same group does appear to be not unlikely; and it may even have been identical with one of them, the period of which has been shown to be probably between 700 and 800 years.

Gibbon must have only intended to amuse himself and his readers when he referred to supposed ancient appearances of the same comet. Whether it is stated that a comet appeared or that Venus "changed her colour, size, figure, and course" in the reign of Ogyges is of little consequence when we consider what a mythical being that personage was. The statement itself is made with regard to Venus; Pingré thought it arose from some tradition respecting the appearance of a bright comet, but speculation as to its course and time of appearance (supposing it to have been one) is quite useless. But as Mr. Chambers, in his valuable and much-read 'Handbook,' has inadvertently quoted the passage as if an object "worthy to be compared with Venus" was mentioned, it may be worth while to give the original (preserved by St. Augustine from Varro) to show that "stella Veneris," or Venus herself, is named as the object said to have undergone such wonderful changes:—"In cœlo, inquit [*i. e.* Varro], extitit portentum, nam in stella Veneris nobilissima, quam Plautus Vesperuginem, Homerus Hesperon appellat, pulcherrimam dicens, Castor scribit tantum portentum extitisse, ut mutaret colorem, magnitudinem, figuram, cursum; quod factum ita neque antea, neque postea sit. Hoc factum, Ogyge rege, dicebant Adrastus Cyzicenus et Dion Neapolites, mathematici nobiles."

One word in conclusion respecting the comet seen after the death of Julius Cæsar in B.C. 44. It appeared, we are told, during seven days whilst games were being celebrated in honour of Venus by Octavian (afterwards the emperor Augustus), and was supposed by the people to indicate the reception of the soul of the murdered dictator into the abode of the gods. Mairan tries to remove the games and the comet from B.C. 44 to 43; but Gibbon refuses to accept this view, and is probably right in doing so. The comet seems really to have appeared in the September following Cæsar's death, which occurred in March, B.C. 44; but of its course in the heavens we know absolutely nothing.

Yours faithfully,

Blackheath, 1887, Aug. 1. W. T. LYNN.

The Variable Star Algol.

GENTLEMEN,—

The variations in the light of this star seem to admit of only one plausible explanation, viz., that Algol is accompanied by a large dark satellite, which transits the disc of its primary at regular intervals. This hypothesis, suggested by Goodricke in 1782, and advocated by Sir John Herschel, has met with wide acceptance in recent years; and, in connection with it, some interesting mathematical deductions have been published by Prof. E. C. Pickering, and by Mr. Maxwell Hall (see the 'Observatory,' No. 48, p. 116, and No. 111, p. 224).

Accepting this hypothesis, we may infer that the masses of the two components are not widely unequal. In this case, Algol must describe about the centre of gravity of the system an orbit of very appreciable dimensions; and, unless the mass of the system be much smaller than that of our Sun, the star's orbital motion must be very rapid. Since the orbit-plane is directed nearly towards our system, it follows that Algol's motion in the line of sight will vary greatly at different times.

In a short article which appeared in the 'Scientific American' nearly fourteen years ago[*], I ventured to suggest that the orbital motion of Algol might be determined by means of the spectroscopic method; but this brief note doubtless failed to meet the eyes of astronomers. Seven years later—in 1881—a similar proposal was made by Prof. Pickering in a paper communicated to the American Academy of Arts and Sciences[†].

It is gratifying to learn that this subject has been receiving attention at the Greenwich Observatory, and that some very suggestive results have been already obtained. The Astronomer-Royal's recent Annual Report[‡] contains the following highly interesting statements with reference to Algol:—"The displacement of the F line in the spectrum of Algol has been measured as frequently as possible during the winter months, in order to ascertain if any evidence could be obtained of rapid orbital motion such as would result from the hypothesis of the variability of Algol being caused by the transits of a large satellite. A sufficient number of observations has not yet been obtained to allow a definite conclusion to be formed, but as far as the observations go there are indications of a variation of the motion in the line of sight corresponding to orbital motions, having the same period as that of the star's variability."

Should these observations be confirmed, the result will not only prove the correctness of Goodrich's hypothesis, but will enable us to draw some important inferences respecting the mass and dimensions of the system.

There are two other points of interest in connection with this subject, which I venture to bring before the notice of your readers:—

(1) It has been shown by Capt. Abney that the axial rotation of a star may modify, to a perceptible extent, the appearance of the dark lines in its spectrum ('Monthly Notices,' Roy. Astr. Soc. vol. xxxvii. p. 278). Now, according to the accepted view, the radius of Algol must bear a considerable proportion to its distance from the centre of gravity of the system. And it is highly probable that the star's rotation-period is either equal to, or shorter than, the period of revolution. The rotation would thus be very rapid, and the resulting effect upon the dark lines of Algol's spectrum would be of a decided character. Further, it will be found, upon examination, that *marked changes in the breadth and shading of the lines would occur during the transits of the dark satellite.* I am not aware that such changes have been noticed, but a large aperture may be requisite for their detection. A negative result—should such be obtained—would be by no means destitute of interest.

(2) It is worthy of notice that the *true* period of Algol's variation may differ from the apparent (or observed) period by an

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[*] Scientific American, Vol. xxix. p. 275 (Nov. 1, 1873).

[†] Proc. Amer. Acad. Vol. xvi.; Observatory, No. 48, p. 116.

[‡] Nature, Vol. xxxvi. p. 139.

appreciable interval. It will be readily seen that the apparent period is affected by the motion of the Algol system (*i. e.* of the centre of gravity) in the line of sight. The latter period has been so accurately determined, that we may distinguish between the two periods, unless the Algol system has no perceptible movement of approach or recession.

Let V denote the velocity of light; μ the velocity of the Algol system in the line of sight (+ denoting *recession*, − *approach*); P', P, the true and apparent periods respectively; $\Delta P = P' - P$.

Then it may be easily shown that

$$\Delta P = -\frac{\mu P'}{V}.$$

In this formula we may write P for P′ without appreciable error. Substituting, then, the numerical values of P and V, we obtain

$$\Delta P = -1^{s}\cdot 33\mu,$$

where μ is expressed in miles per second.

If, for example, the Algol system were approaching our system at the rate of 30 miles per second, the true period would be about 40 seconds *longer* than that found by observation, or $2^{d}\ 20^{h}\ 49^{m}\ 34^{s}$, the observed value being $2^{d}\ 20^{h}\ 48^{m}\ 54^{s}$.

In conclusion, it is probable that the spectroscopic method may be successfully applied to other stars of the Algol type; but the comparative faintness of these stars will render it necessary to employ a very large aperture for this purpose.

Yours truly,
J. M. Barr.

St. Catharine's, Ont., Canada,
1887, July 8.

The Periods of the Planets.

Gentlemen,—

As Bode's law relating to the distances of the Planets is no longer defensible, it occurred to me to seek for some numerical relations among their periods like those which obtain among the periods of the satellites of Jupiter and Saturn. Taking the outer planets, which seem to form a class in themselves, I found an approach in their periods to the numbers 2, 5, 14, and 28. The unit of this scale would be an asteroid or minor comet with a period of about 5·90 years. This would give:—

	Computed Periods. Years.	Observed Periods. Years.
Jupiter............	11·80	11·86
Saturn............	29·50	29·46
Uranus	82·60	84·02
Neptune	165·20	164·78

The observed periods are alternately in excess and defect of the computed, a state of things which might well occur if the periods were originally commensurable.

Following the foregoing example, I assumed as the unit of scale for the four inner planets an intra-Mercurial planet with a period of 12·5 days, rather for convenience than because there is any adequate ground for believing in its existence. I then found their periods fairly represented by the numbers 7, 18, 29, and 55, with the same alternate excess and defect as before.

	Computed Periods. Days.	Observed Periods. Days.
Mercury	87·5	87·97
Venus	225·0	224·70
Earth..............	362·5	365·26
Mars	687·5	686·98

Considering the short period of the hypothetical planet with which I start, the error in the case of the Earth is considerable. Nevertheless, the periods of Mercury and the Earth are very nearly in the proportion of 7 to 29. As in the former instance, the principal deviation occurs in the case of the third planet of the four.

Denoting by m the period of Mercury, M that of Mars, and the periods of the other planets by their initial letters, the following simple relations are very nearly correct:—

$$15m = 3E + V.$$
$$2M + m = 4E.$$
$$5(E - m) = 3(M - V).$$
$$M + 2E = 2V + 11m.$$
$$2M + 16m = 7E + V \text{ (correct to less than one hour).}$$

Others will no doubt be discovered by examination. The table gives $E + m = 2V$, but in this case the error is nearly 4 days.

The relations among the outer planets appear to be less simple, as $5J = 2S$ and $N = 2U$ are by no means accurate. Indeed some of the differences between expressions which should vanish according to the table appear to be commensurate with the periods of the inner planets, but the coincidence is not very exact considering the comparatively short periods of the latter. Thus $U - 7J$ is nearly equal to one year, $5J - 2S$ to $\frac{2}{5}$ years, and $14J - N$ to $1\frac{2}{7}$ years. $2U - N = 2(E + V)$ is also nearly correct, but the exact period of Neptune is doubtful to an extent comparable with the periods of some of the inner planets. One of the most exact relations among the outer planets alone is given by

$$39J = 8S + 2U.$$

The nearest approach to accuracy in the tabular values is with the periods of Saturn and Neptune, the ratio of which is not far from 5 to 28. Somewhat similar occurs with the second and fourth planets in the inner series.

Yours truly,
W. H. S. Monck.

Dublin, 1887, July 14.

The Orbits of Comets.

GENTLEMEN,—

In an interesting sketch of Dr. Braun's 'Cosmogony,' by Miss A. M. Clerke, in a late number of 'Nature,' I find the following remarks on the above subject:—

"Comets can no longer be set down as mere casual intruders upon the solar system. They certainly share its translatory motion since, if they were either overtaken or encountered, they would seem to come most numerously from near the apex of the Sun's path. But they approach him indifferently from all parts of the sky. A further proof of the absence of relative motion is afforded by the shape of the tracks they pursue. M. Faye has remarked that of 364 cometary orbits calculated not one is a decided hyperbola, and Laplace's view that they are hyperbolic by nature and elliptical only through perturbation is thus seen to be the exact reverse of the truth."

I have already urged in your columns that a number of comets which are distinguished by direct motion, small inclinations, short periods, marked ellipticity, and apparent connection with Jupiter (or some other planet) are original members of the solar system. But these constitute a comparatively small class, and I think there are good reasons for regarding the majority of comets as mere intruders on the solar system from space.

It is not, I think, quite correct to say that comets come to us indifferently from all quarters of the heavens. On the contrary, there seems to be a preference for particular directions, which preference is not explained by anything within the solar system. That they show no decided preference for the apex of the Sun's path probably arises from the fact that they are not uniformly distributed in space but are massed in particular regions. The motion of the solar system being rather slow, its effect is masked by the irregularities of cometary distribution.

But the question of the relative number of elliptic and hyperbolic orbits is worthy of further consideration. Both mathematical and physical considerations lead us to think that true parabolic orbits are very rare; yet, until 200 or 250 years ago, we do not possess observations of sufficient accuracy to enable any other than a parabolic orbit to be computed. The same remark holds good of many subsequent comets; and if I exclude the class of comets which seem to me to belong to the solar system (for the reasons already stated), there are few elliptic comets in which the deviation from the parabola is of a marked character. As a rule, the deviations are not greater than those of the six comets classed as hyperbolic in Mr. Chambers' Catalogue. Nor is the total number of these elliptic comets very large; it probably does not exceed ten times that of the hyperbolic.

But if there are ten elliptic comets to one hyperbolic, does not this show a great preponderance of the former class? It may, or it may not. All depends on the average duration of the existence of a comet and the average period of an elliptic comet. Suppose, for instance, that an average comet exists for a million years and the average period of an elliptic comet is 10,000 years, then each elliptic comet may be expected to visit us 100 times before its extinction; and elliptic comets ought to be 100 times as numerous as hyperbolic, supposing the absolute frequency of both classes to be the same. To put it in another way. Six hyperbolic comets paid us their first (and only) visit during the last 200 years. Is it certain that six elliptic comets paid us their *first* visit during the same period? If 10,000 troops passed through a town of 10,000 inhabitants every year, a resident there would see more inhabitants than troops in any year, because the inhabitants would be constantly going backwards and forwards while the troops passed through but once. The case of elliptic and hyperbolic comets is similar.

Yours truly,
W. H. S. MONCK.

Dublin, 1887, Aug. 14.

Colour of eclipsed Moon 3rd August.

GENTLEMEN,—

Now that the peculiar sunset glows of 1883 and the following year or two are gone, the eclipsed surface of the Moon seems to be assuming its normal colour. A fine after-glow on the evening of 4th October, 1884, was followed by an almost black total eclipse of the Moon. What is worthy of note is that the two lunar eclipses in the following year, which under ordinary circumstances would have displayed a large amount of the dull red or coppery hue, were precisely similar in character to that of 1884. With regard to the eclipse of 30th March, 1885, which attained a magnitude of nine-tenths of the Moon's surface, Mr. A. B. Biggs writes, in the 'Launceston Examiner' (a Tasmanian newspaper) of 1st of April, that the usual coppery tint was entirely absent. His words are. "Although the eclipse of last night was not total, it was so nearly so as to be of very considerable interest in relation to its appearance in shadow. . . . . As the shadow advanced that part adjacent to each limb appeared considerably lighter than the general shadow. At this time about fifteen degrees of the Moon's limb on each side was visible within the shadow, increasing during the middle of the eclipse to about 25 degrees; this portion of the edge appeared as a sharp line of light gradually fading away into the shadow. With the above exception, all within the shadow was utterly obliterated—lost in the dead slaty tint of the sky. I could not distinguish a single crater after once it was fairly within the shadow. Not the slightest trace of the coppery tint was visible throughout." Similar testimony is borne by a New South Wales correspondent to the eclipse of the following September. But the eclipse of last Wednesday (August 3rd) indicated the appearance of a certain amount of the old tint, though not so vividly as I have formerly noticed in a smaller eclipse (that of 4th October, 1865). At 8·35 on the 3rd, a strong brownish hue came over the obscured limb, lasting for twenty minutes or so, the whole lunar circle was easily seen, though separate points of detail could not be made out. The absence of the coppery tint, directly the sun-glows began (it had been conspicuous enough in Dec. 1881), and its indications of reappearance after the said glows had vanished, seem to indicate some connection in the way of cause and effect.

Yours faithfully,

Melplash Vicarage, Dorset.
1887, Aug. 8.

S. J. Johnson.

Method of regulating Clocks.

Gentlemen,—

My attention has been called by Mr. R. L. Jones to some remarks which I made at the May meeting of the Royal Astronomical Society, with reference to his method of regulating clocks. The method there described is a modification of Mr. Jones' method which was applied to several clocks by Sir G. B. Airy. I was under the impression that this modification was due to Mr. R. L. Jones, and that it had superseded his original plan, according to which "the pendulum bob is a hollow coil oscillating over two or more fixed magnets, two in the length of its arc and placed with the similar poles nearly together." It appears that I was mistaken in this impression, and Mr. Jones informs me that he has reason to think that his plan has in no case failed. It is to be understood, therefore, that M. Cornu's researches have reference to the modified form of Jones' method of regulation, not to the form adopted by Mr. Jones himself.

Yours faithfully,

Royal Observatory, Greenwich,
1887, Aug. 4.

W. H. M. Christie.

NOTES.

The Total Solar Eclipse of August 19.—It is probable that the preparations for the observation of a solar eclipse have never been so extensive and complete as for that just past. Besides the prosecution of the spectroscopic examination of the corona and chromosphere in their various layers, which has formed so important a feature in recent eclipse expeditions, the photographing both of the corona and its spectrum, and the search for intramercurial planets, it was intended by observations of the eclipse at stations on either the northern or southern boundary of the shadow, to determine the precise ratio of the apparent diameters of the Sun and Moon, the stations being distributed as follows:—

SOUTHERN BOUNDARY.

Station.	*Observer.*
Soprikino.	Ludwig Struve.
Gschatzk.	Lieut. Drischenko.
Moscow.	Wittram, Lorentzen.
Vladimir.	Fuss, Sacharoff, Schubin.
Balachna.	An assistant of Kortazzi.
Urshum.	An assistant of Dubjago.

NORTHERN BOUNDARY.

Station.	*Observer,*
Dunaburg.	A. Döllen.
Velikie Luki.	Capt. Korloffski.
Perovino.	Prof. Otto Struve, Majeffski.
Jaroslav.	Lieut. Prince Galitzin.
Kostromo.	An assistant of Kortazzi.
Orloff.	An assistant of Dubjago.

The observers of the total eclipse proper formed a very large and goodly company, and were distributed over as long a line as possible, so as to minimise the chance of disappointment through bad weather, as the following list of the stations occupied in Russia will show:—

Rshew.—From the Princeton Observatory, Prof. Young for spectroscopic observations on the "flash," 6-inch equatoreal and diffraction-grating; and McNeill for photographs of the corona.

Prof. Libbey and three ladies, for photographs of the corona.

Capt. Witroffsky.

Savidovo.—From Count Ferrari's private observatory at Rome, Padre Conte Ferrari, Lais, and Buti, for photographs of the corona, and experiments on the solar radiation during the eclipse.

Schipulino.—From Pulkowa Observatory, Prof. Hasselberg and Dr. Renz for photographs of the spectrum of the corona and eye-observations of the spectrum.

From Potsdam Observatory, Prof. Müller, Drs. Kempf and Scheiner for photographs of the corona, with revolving slide to take eight pictures; and meteorological observations.

From Helsingfors Observatory, Dr. Donner for the search for an intramercurial planet.

Wyssokoffsky.—From Greenwich Observatory, Mr. Turner for spectroscopic eye-observations and photographs of the corona. Count de la Baume, from Paris, for photographs of the corona with 12-inch reflector.

Near Klin.—From Milan, Grassi, Colombo, and Stoppani for photographic observations of the corona.

Nikolikojo.—Jegoroff, Wutschithoffsky and party.

Petrovsk.—From St. Petersburg Observatory, Prof. Glasenapp for search for intramercurial planets, and Tatschaloff for photographs of the corona.

From Meudon Observatory, Dr. Stanoiewitsch for photometric determination of light of the corona by means of photography.

Ivanova.—From Brown University, Providence, Rhode Island, Prof. Upton for meteorological observations, Mr. Roatsch; and from Seewarte, Hamburg, Dr. Köppen, also for meteorological observations. Some 170 stations promised to assist Prof. Upton in the work of determining the influence of the eclipse on the barometer.

Kineschma.—From Moscow Observatory, Prof Bredichin.

From Stonyhurst Observatory, Rev. S. J. Perry, for photographs of the corona and its spectrum.

From Dun Echt Observatory, Dr. Copeland, also for photographs both of the corona and its spectrum.

From the Liverpool Astronomical Society, Miss Brown.

Turjevetz.—From Moscow Observatory, Bjelopolsky; and from Nicolaieff, Kortazzi.

Varnavin.—From Moscow Observatory, Ceraski.

On the River Viatka.—From the Observatory of the Roman College, Prof. Tacchini. From Palermo Observatory, Prof. Ricco. Both for spectroscopic observations.

Kleiber; Dubjago.

Perm—From Brussels Observatory, Niesten.

Krasnojarsk.—Chamoutoff and party.

An American expedition provided with the means both of photographic and spectroscopic observation was likewise stationed in Japan.

Unfortunately the weather proved almost wholly unpropitious. In Eastern Prussia the failure was all but complete, some partially successful attempts being secured only at Nordhausen and Eisleben. In Russia too, with the exception of the one station of Petrovsk, there was the same dismal record of cloud, rain, or mist, everywhere. At Klin, Prof. Mendelieff, in order to baffle the thick clouds and drenching mist, gallantly made his first balloon ascent, alone, unfortunately too late for any important result. Another balloon that went up from Tver met with torrents of rain in its ascent. At Spirovs the total phase was said to have been visible for twenty seconds. At Petrovsk, the one fortunate station, Professor Glasenapp made six drawings and took two photographs of the corona; Dr. Stanoiewitsch took a series of photographs; and Professor Kononovitsch, of Odessa, observed a complete spectrum of the corona.

The failure of the expeditions to the Russian stations is the more regrettable, as they seemed to have been planned with every possible care, and the astronomers who came to them from other lands speak in the highest terms of the trouble taken by Professor Struve and other leading Russian astronomers to furnish them with every requisite information and help, and of the ready courtesy, hospitality, and assistance which they met with on every hand. The only hope of results from the eclipse lies now with observers in Northern Asia and Japan. At Tomsk and other Siberian stations the weather was superb, but unfortunately, owing to the distances to be travelled and the difficulties of transport, only one or two astronomers cared to penetrate far into Siberia, and these were not by any means so elaborately equipped as the observers in European Russia.

The following communication has been received by the Secretary of the Liverpool Astronomical Society from Miss E. Brown, the Director of the Solar Section, who had gone to Kineshma, where Dr. Copeland and the Rev. S. J. Perry were the guests of Prof. Bredichin:—

"Kineshma, August 20.—Long before this reaches you telegrams will have announced that here we were disappointed in our hopes of seeing the eclipse. For a few days previous to the eclipse the weather had been fine, two days of almost continuous rain having cleared the air; but it was with faint hearts that we retired to rest on the evening of the eventful day. Professor Bredichin announced as we parted that he was almost without hope. Looking out after the sun had risen on the 19th, I found the sky already obscured with clouds, but the clearness over the horizon gave a little ray of hope. This was much increased when, on looking over the balcony at a quarter to six, I saw a patch of blue sky. By this time the final preparations were being rapidly completed. A hasty breakfast was swallowed, and, on repairing to the court-yard—where the large and complicated instruments of our astronomers were standing, bristling with cameras, and everything in order—I found each observer ready at his post. The last rehearsals were rapidly gone through. The white-faced clock was standing in front, ticking off the ten seconds with regular beat, and having a double row of figures to mark within the outer circle how much time would remain to be employed during the precious 130 seconds of the total phase. At six the sun shone out clearly, and the light on the horizon continued, but the ominous scud-clouds kept drifting up, and through them we could see the dark disk of the moon, slowly but surely creeping over the luminous surface of the sun. Alas, our hopes were soon to be dispelled. The darkness deepened; the grass assumed a peculiar hue; candles were about to be lighted, but the clouds—those enemies to astronomical observation—grew thicker. Totality commenced. For one second the corona was visible, giving almost the appearance of an annular eclipse, and the flash of rose-coloured prominences showed what might have been. In two and a half minutes a voice cried 'The eclipse is over,' and there was nothing for it but to make the best of our disappointment and begin packing up; only hoping that observers further east had been more successful."

The end of the partial phase was watched under favourable circumstances from several places in England. It is, of course, only the total phase which has any great scientific interest, but a curious phenomenon was observed on the partly hidden disk of the sun as it rose above the horizon, which excited some comment, viz. the presence of a thin black line. A correspondent who saw the eclipse under very good conditions from the Malvern Hills writes as follows:—

"The dawn of the 19th was simply perfect. I watched the sun from its first appearance as a brilliant ruby spot till it was too bright for the eye to bear. The small remaining portion of the dark moon was distinctly visible, also the thin black line which has been mentioned in the papers, which was seen across the Sun's disk as soon as it was above the horizon. What struck me as still more curious, and which I have not seen mentioned, was a second dark line, curved like a crescent, following the line of the Sun's edge on the left hand. I could see it as long as I could bear to watch, having unfortunately no dark glass. This curved line appeared some minutes later than the straight line."

FLAMSTEED'S STARS "OBSERVED BUT NOT EXISTING."—In Baily's account of Flamsteed is found a list of stars with the above heading, which means "stars of which the observations appear to be accurately recorded, but which still cannot now be found in the heavens." This list has often been referred to as evidence that stars have actually disappeared from the heavens since Flamsteed's time. The labours of Bode, Caroline Herschel, Argelander, and Baily disposed of all these supposed "missing" stars, with the exception of 22 which eluded their explanation. Dr. C. H. F. Peters has investigated closely and accurately these 22 stars, and the exhaustive results which he has just published in the 'Memoirs' of the American National Academy of Sciences afford in almost every case a satisfactory explanation of the observations, and an identification of the object really observed, finally disposing of the erroneous idea that any of these stars had actually been extinguished, and accounting for all the stars in the British Catalogue as well as the positions will permit.

Perhaps the most interesting identification is that of the star "Baily's Flamsteed 1647," which was asserted by Argelander to be the planet "Uranus," but this view was rejected by Baily on account of the supposed great difference in the declination. Dr. Peters has rigorously computed the position of Uranus for the epoch, and the comparison with the observation (adopting Argelander's reduction) gives—Difference (C—O), Æ $+1^{s}\cdot23$, and Decl. $-1''\cdot0$, completely vindicating Argelander's suggestion. Dr. Peters remarks that, perhaps misled by Baily, no notice has been taken of this observation in the recent tables of Uranus.

The author concludes this interesting paper by strongly urging the desirability of a new reduction of Flamsteed's observations. "The astronomical world has not yet done justice to the sacrificing zeal, the industry, the honest work of the first Astronomer Royal. Has England no young astronomer ambitious to undertake the task?"

CORRIGENDA IN VARIOUS STAR CATALOGUES.—Astronomers owe a debt of gratitude to those whose careful scrutiny has revealed and corrected errors in star catalogues. Under the above title, Dr. C. H. F. Peters has published, in Vol. iii. of the 'Memoirs' of the National Academy of Sciences at Washington, an extensive series of corrigenda which he has detected in the following catalogues, and which are hitherto unknown:—Oeltzen's Catalogue of Argelander's Southern Zones, the Catalogues of Vol. vi. of the Bonn Observations, Weisse's Bessel (both Catalogues), Rumker's Catalogue of 12,000 Stars (original Catalogue and the New Series), Schjellerup's Catalogue, Baily's Lalande, Yarnall's Catalogue (2nd edition), the Glasgow Catalogue, Moesta's Santiago Observations, and the Geneva Observations, 1842–49. The paper also includes a list of 191 "Anonymous" Stars in Yarnall's Catalogue which Dr. Peters has identified in other catalogues. The value of these corrections will be appreciated from the statement of the author that he has "not been content with the simple fact of an error, but has mostly turned to the original observations, when accessible, in order to discover the source of error."

TOMLINSON'S "PNEUMATICS"*.—In this little work the constitution of the atmosphere is explained, and its physical properties experimentally illustrated in a manner sufficiently clear and satisfactory; and the various useful machines and contrivances depending for their action on the pressure of the atmosphere are fully described. In these respects the book will probably very well fulfil its intended object, although, as regards special information, it is scarcely up to date. There is, for instance, much that is interesting concerning meteorological instruments; but yet, on some points, an erroneous impression is conveyed. To take the barometer as an example, the author, quoting Prof. Daniell (p. 43), says, "In the shops of the best manufacturers and opticians I have observed that no two barometers agree; and the difference between the extremes will often amount to a quarter of an inch," without pointing out that this sweeping statement can hardly be said to now apply. He speaks of Prof. Daniell's platinum guard as preventing that deterioration of mercurial barometers caused by infiltration of air, but we do not know that this contrivance ever came into general use,—the manufacture of barometers being now, indeed, so much more certain that in good instruments no defect of this kind need be feared. Again (p. 52), it is stated that it is usual to reduce barometer readings to the temperature of 32° for the sake of comparison, and that the height of the cistern above sea-level, and its index error, if possible, should be obtained. Rather should it be said that, for any scientific use, these things are *necessary*. The siphon barometer is spoken of (p. 53) as being inferior to the cistern barometer because of the halving of the range of motion of the mercury, and it is recommended that the upper end be expanded into a bulb. But this is unphilosophical and introduces scale difficulties, the siphon with equal bore above and below having scale to read both surfaces being indeed with some observers a favourite form of standard instrument. As regards self-recording barometers, those of Milne and Stevenson are described, other vastly superior modern forms, as King's and others, remaining unnoticed. In the diurnal movement of the barometer the two maxima and two minima do not (p. 103) always occur at the same hours, but vary considerably in time between summer and winter. These and other similar points should receive attention in any future reprint. Speaking of anemometers (p. 135), the most common forms are said to be those of Whewell and Osler. Rather these are very rare forms, that of Robinson, with revolving cups, being the form now for many years almost universally adopted. There is altogether a good deal of interesting information on instruments in the book, but it requires sifting and rearrangement, and whilst some things might be omitted, there are others which could with advantage be incorporated. Acoustics are not touched upon at any very great length.

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* 'Pneumatics, including Acoustics and the Phenomena of Wind-Currents, for the Use of Beginners.' By Charles Tomlinson, F.R.S., F.C.S. Fourth edition, enlarged. Weale's Rudimentary Series, No. 12. London: Crosby, Lockwood and Co.

THE MEUDON OBSERVATORY[*].—M. Janssen, reporting on the work accomplished at the Meudon Observatory, lays especial stress on the solar photographs which have been obtained there, and which afford a history of the solar surface for the past ten years. It has been his chief aim to bring to perfection the method of obtaining sun-pictures, and he has so far succeeded that he has been able to present upon the same plate the details both of the brightest parts of the Sun and of the less luminous portions. The great spot of June 22, 1885, of which M. Janssen had secured a very beautiful and important photograph, had shown that the striations of the penumbra and the faculæ surrounding it were composed of granulations similar in form and shape to those which make up the general surface of the Sun; and the beautiful circular spot of the past July has given a precisely similar result. The better the definition of any solar photograph, the more evidently is this feature brought out; and M. Janssen concludes that we may infer that the entire surface of the Sun is constituted after a uniform manner, and that those elements which we call granulations are in truth the constituent elements of every portion of the surface. M. Janssen also referred to the preparations made for observing the late solar eclipse, and to the results of his experiments on the absorption of gases. His experiments in the case of oxygen have shown him that its absorption-spectrum is of two orders, one of lines and one of bands. The system of bands seems to be governed by the law of the square of the density, whilst the system of lines follows that of the simple density; that is to say, that the dark lines have an intensity proportional to the product of the length of gaseous column into its density, but the dark bands to the product of that length by the square of the density. This property renders it possible to obtain the lines without the bands, or the bands without the lines, or even both at once.

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[*] Comptes Rendus, Vol. cv. No. 7.

MAGNITUDES OF STARS EMPLOYED IN NAUTICAL ALMANACS.—With a view to expediting the publication of short articles upon astronomical and meteorological subjects which may be prepared at the Harvard College Observatory, Prof. Pickering has decided to print and publish each as soon as it is prepared as a separate number of a series which, when a sufficient amount of material has thus been collected, will constitute the XVIIIth volume of the Annals of the Observatory. The first of this series is on the subject of the magnitudes of the standard stars of the various Nautical Almanacs, Prof. Pickering having remarked that the different Almanacs often varied much as to the brightness to be assigned to any particular star, whilst, generally speaking, the best attainable determinations of magnitude had not been employed. Prof. Pickering offered, therefore, to supply to the Superintendents of the different Almanac Offices a discussion of the magnitudes of the standard stars as derived from the best modern determinations, and received favourable replies in every case except the Almanacs of England and Germany; it is therefore to be expected that the French, Spanish, and American Nautical Almanacs will in future give more precise values for the magnitudes of their stars.

The plan adopted in the paper is to give for each star a magnitude derived from the mean of those supplied by four standard authorities, viz. the 'Harvard Photometry' (M), the 'Uranometria Argentina' (A), Wolff's photometric observations (W), and the 'Uranometria Oxoniensis' (O); the second and third being reduced to the scale of the Harvard Photometry, the Oxford catalogue not needing such reduction. The stars of the five Almanacs are altogether 800 in number, some few, 64 in all, occurring in only one of the four authorities for magnitude, but the majority are given by three, and 132 by all four. The agreement between the four authorities is sufficiently close for the most part; out of 2188 residuals only 67 exceed two-tenths of a magnitude, and only

17 exceed three-tenths, the average probable error of an adopted magnitude being 0·09 on the assumption that all systematic errors have been removed. The large residuals are distributed between the four authorities as follows :—

Residuals.	M.	A.	W.	O.
0·3	5	14	14	17
0·4	1	6	1	7
0·5	0	0	0	1
0·6	0	0	0	0
0·7	0	0	0	1

The residual of 0·7 occurs in the case of the double star θ Serpentis.

BREAK-CIRCUIT CHRONOMETERS.—In reference to his letter on this subject in the March number of the 'Observatory,' p. 140, Prof. Young has pointed out to us that the earliest example of a break-circuit chronometer seems to have been of English make, one having been constructed in 1869 by Messrs. Parkinson and Frodsham for the use of Prof. Winlock, at that time director of the Harvard College Observatory. The following reference to it occurs in Vol. viii. of the 'Annals' of that Observatory, p. 19 :—

"Two other chronometers, both by C. Frodsham, were procured by Prof. Winlock. . . . No. 3451, bought in 1869, is provided with a galvanic attachment for use with the chronograph. It is one of the first chronometers ever adapted to this purpose (the construction of such instruments having been originally suggested to Mr. Frodsham by Prof. Winlock), and has repeatedly been used in the determination of longitudes. Its excellence has brought it into occasional use as the standard time-piece of the Observatory at times when the South Clock required repairs."

ACHERNAR.—Mr. Herbert Sadler writes to us with reference to Messrs. Williams and Chambers's letters on the colour of Achernar ('Observatory,' Vol. ix. pp. 272 and 301) to point out that Engelmann's original observations as recorded in the Astr. Nachr. Vol. 77. p. 54, show that "the observation was made at Bijapur, at a time when Achernar was less than 8½° above the horizon. Only two observations of the magnitude of Achernar are given, and no colour was noted on the 15th of August 1868, when the star was higher than on August 23rd, when its colour was noted as 'roth.' Every other observer has seen Achernar white, and Engelmann's colour is manifestly due to the low attitude of the star" on that one particular occasion.

Mr. Sadler also calls attention to No. 648 in Mr. Chambers's Catalogue of Red Stars in the April number of the 'Monthly Notices,' as no star exists at the place given. A similar error existed in the case of No. 265 of his former Catalogue.

PARTIAL LUNAR ECLIPSE OF AUG. 3, 1887 [*].—This eclipse differed notably from the lunar eclipse of Oct. 4, 1884, in that the eclipsed portion of the Moon remained visible in a telescope and showed no very intense coloration. The spectrum of the shaded zone lying between the part of the Moon in full shadow and the part still illuminated was examined by M. Rayet with the three-prism spectroscope of the Bordeaux observatory. In the spectroscope the division between these two districts was very sharp; whilst the spectrum of the eclipsed portion was bounded by the D and F lines, and was brightest near E, that of the part of the Moon on which the transition from darkness to light took place extended sharply towards the red as far as the atmospheric group α of Angström's map. The lunar spectrum was too faint, especially in the district near the eclipsed portion, to allow the use of a slit sufficiently narrow to show the atmospheric lines; the group α and the many lines near D alone being visible under the form of bands.

NEW VARIABLE STAR IN THE RING NEBULA IN LYRA.—Herr Spitaler, writing to the Astronomische Nachrichten, No. 2800, calls attention to the apparent variability of the small star near the centre of this nebula. The star had been shown on a photograph of the nebula taken by Herr E. von Gothard, but Herr Spitaler found himself unable to detect it in his examination of the nebula during the autumn of 1886. In July of the present year, however, whilst Prof. C. A. Young was at the Vienna Observatory, he examined the nebula again, and both observers readily perceived the missing object.

THE ALGOL-TYPE VARIABLE, Y CYGNI [†].—Mr. Sawyer publishes some observations he obtained last winter of the new Algol-type variable discovered by Mr. Chandler ('Observatory,' Vol. x. p. 110) in the constellation Cygnus. The observations afford a general confirmation of Mr. Chandlers's elements ('Observatory,' Vol. x. p. 142), and give no evidence of a further subdivision of the period.

NEW VARIABLE STAR.—Mr. Espin, in the 17th circular of the Wolsingham Observatory, states that observations since 1885 show that the star Birm. 541 is variable from 6·6 ± to 8·0 ±. The star's place for 1887 is R.A. $20^{h}\ 9^{m}\ 17^{s}$, Decl. $+38^{\circ}\ 22'\cdot0$.

DISCOVERY OF A COMET.—Mr. W. R. Brooks, Phelps, Ontario County, New York, discovered a comet on Aug. 24, $20^{h}\ 53^{m}$ G.M.T. Position of comet:—R.A. $8^{h}\ 33^{m}$, Decl. $29^{\circ}\ 0'$ N. This is probably a return of Olber's comet.

THE LATE MR. ALVAN CLARK.—We greatly regret to report the death of the great American optician Mr. Alvan Clark, who died at Cambridgeport, Mass., on Aug. 19, in the 84th year of his age.

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[*] Comptes Rendus, Tome cv. No. 6.

[†] Gould's Astronomical Journal, No. 159.

Mr. Clark, who was born at Ashfield, Mass., on March 8, 1804, had few or no educational advantages, and was thrown entirely on his own resources at the early age of 17. His energy and industry soon opened for him a career; he taught himself engraving and portrait painting, and in 1826 he was working as an engraver of rolls for calico printers at Lowell. He also employed himself in painting miniature portraits on ivory, an art in which he became so skilled that in 1835 he opened a studio in Boston, removing in the following year to Cambridgeport. Here he took up the study of astronomy as a means of recreation and mental improvement, and attempting to grind his own lenses it was not long before he learned how to make them of first-rate quality. The lenses he made at first were but of small aperture, but their fine definition and the observations he was enabled to make with them, attracted the attention of the well-known observer the Rev. W. R. Dawes, who brought them under the notice of the scientific world. Thus with a telescope of 8¼ inches aperture he discovered that 99 Herculis was a double star, and in 1856 that the companion of μ Herculis was likewise double. One of his first large telescopes was one of 12 inches aperture for the Vienna Observatory; the first large one for an American Observatory being the great 18-inch refractor now at the Dearborn Observatory, but which was built for the Mississippi University. With the assistance of his two sons he has produced yet greater lenses than this, his greatest triumphs having been the 26-inch object-glass of the Naval Observatory, Washington, and the 30-inch lens of the Pulkova Observatory. He lived to complete also, but not to see the final installation of his masterpiece, the great object-glass for the Lick Observatory, 36 inches in diameter. Mr. Alvan Clark was a Member of the Philosophical Society of Philadelphia, and of the American Academy of Arts and Sciences; and was granted the honorary title of M.A. by the Harvard University.

We regret also to notice the death of another distinguished American man of science, Dr. Spencer Fullerton Baird. Dr. Baird's personal work had not indeed lain in the field of astronomy, but as Secretary of the Smithsonian Institution he was brought into immediate relationship with the workers in every department of science, and astronomers, and not ornithologists alone, may well deplore his loss.

Mr. Howard Grubb, F.R.S., the well-known telescope and instrument maker, received the honour of Knighthood from the Lord Lieutenant of Ireland on Monday, August 22.

Change of Address.—The notice of correspondents and subscribers is called to the Editors' change of address, from Hyde House, Royal Hill, Greenwich, S.E., to Hyde House, Ulundi Road, Westcombe Park, Blackheath, S.E.

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE
Twelfth Meeting of the Astronomische Gesellschaft, 1887, August 29 to 31 337

Articles:—

Airy's Numerical Lunar Theory. By M. R. Radau 339
Account of further Observations of the Lunar Crater Plato in the years 1882–84. By A. Stanley Williams, F.R.A.S 345
Meteor Notes. By W. F. Denning, F.R.A.S. 351
Selenographical Notes. By T. G. Elger, F.R.A.S 354

Correspondence:—

The Comet discovered by Montaigne and Olbers in 1780. By W. T. Lynn, B.A., F.R.A.S. 355
The Variable Star Algol. By W. H. S. Monck, M.A., F.R.A.S 357
The Determination of Meteor-paths and Radiants. By W. F. Denning, F.R.A.S. 358
Lalande 26481. By John Tebbutt, F.R.A.S. 360

Notes:—

New Variable.—The Spectra of Hydrogen and Water Vapour.—Nice Observatory.—The Oxford Uranometria.—The Wedge Photometer.—The supposed Satellite of Venus.—New Observatory.—New Variable Star of the Algol-type.—Publications of the Morrison Observatory.—The Leander McCormick Observatory.—The Nomenclature of Double Stars.—The Transit of Venus, 1882.—Total Solar Eclipse of August 19.—θ^1 and θ^2 Tauri.—New Minor Planet.—Editorial Note 361–368
Elements and Ephemeris for Olbers' Comet. By A. Lebeuf 368

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CONTENTS OF No. 127.

Articles:—

Page
Theodor von Oppolzer 309
Meteor Notes. By W. F. Denning, F.R.A.S. 313
Selenographical Notes. By Thos. Gwyn Elger, F.R.A.S. 316

Correspondence:—

Suggested Mean Distances of Ultra-Neptunian Planets. By W. T. Lynn, F.R.A.S. 318
The Comet of 1680 and its supposed previous appearances. By W. T. Lynn, F.R.A.S. 318
The Variable Star Algol. By J. M. Barr 320
The Periods of the Planets. By W. H. S. Monck, M.A., F.R.A.S. 322
The Orbits of Comets. By W. H. S. Monck, M.A., F.R.A.S. 324
Colour of eclipsed Moon 3rd August. By the Rev. S. J. Johnson, F.R.A.S. 325
Method of regulating Clocks. By W. H. M. Christie, M.A., F.R.S. 326

Notes:—

The Total Solar Eclipse of August 19.—Flamsteed's Stars "Observed but not Existing."—Corrigenda in various Star Catalogues.—Tomlinson's "Pneumatics."—The Meudon Observatory.—Magnitudes of Stars employed in Nautical Almanacs.—Break-circuit Chronometers.—Achernar.—Partial Lunar Eclipse of Aug. 3, 1887.—New Variable Star in the Ring Nebula in Lyra.—The Algol-type Variable, Y Cygni.—New Variable Star.—Discovery of a Comet.—The late Mr. Alvan Clark.—Editorial Notes 326–336

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THE OBSERVATORY,

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No. 128. OCTOBER. 1887.

Twelfth Meeting of the Astronomische Gesellschaft, 1887, *August* 29 *to* 31.

This meeting was held at Kiel University, and was attended by many Continental astronomers. The President, Privy Counsellor A. Auwers, of Berlin, occupied the chair. A large portion of the first sitting was taken up in reading reports and in the business of the Society.

Prof. C. H. F. Peters, of Clinton, expressed a wish that the stereotype plates of Gould's 'Zone Catalogue,' which were in the possession of the Society, might be used in order to place a copy of the Catalogue in the hands of each member. The question was referred to a Committee.

The President then announced that the idea of publishing a General Index for the first 100 volumes of the 'Astronomische Nachrichten' had been given up, but that measures had been taken to publish an index of Volumes 81 to 120, and it was to appear soon after the issue of the last-named volume.

Prof. C. H. F. Peters showed some photographs of the MS. of the 'Almagest,' and stated that he was opposed to the view that the observations were produced by Hipparchus and reduced by Ptolemy to his own time. He found in the Catalogue itself reasons for distrusting this opinion. He inclined to the view that the observations were made in the time of Ptolemy, and that the observations for latitude were made with two instruments, while those for longitude were made with only one.

Prof. E. Weiss showed two star-charts, one dated 1512, the other 1515. The star-places were obtained by Stabius, and the artistic ornamentations were executed by Albrecht Dürer.

Prof. C. F. W. Peters made some remarks on the influence of humidity on the rates of chronometers. He had found very large differences in the daily rates due to this cause. He found no influence due to magnetism.

At the second sitting the question of the publication of the

Ephemerides of small planets was brought forward. The Editors of the 'Berliner Jahrbuch' proposed to discontinue them after the year 1890; but at the same time invited discussion.

Prof. C. H. F. Peters opposed any alteration in the present manner of publication.

Dr. H. Oppenheim thought that by only giving the ephemerides for the times of opposition much space would be saved in the 'Jahrbuch.'

Prof. C. H. F. Peters remarked that a complete ephemeris was necessary for those astronomers engaged in the search for small planets.

Dr. Schönfeld opposed the curtailment on the ground that the ephemerides were already insufficient for the purposes of photometric observations.

A Committee was appointed to decide the question.

Prof. C. H. F. Peters presented two papers reprinted from the Memoirs of the National Academy of Sciences, Vol. iii.—one, "On Flamsteed's Stars observed but not existing;" and the other, "Corrigenda in various Star Catalogues."

Then followed the reports on the state of the zone observations at each observatory engaged in the work.

Dr. Wolff presented his report on photometric work. His preliminary result for the photometrical logarithmic ratio of the Durchmusterung was 0·36. (That used by Pickering and others being 0·40.)

Freiherr v. Haerdtl, a pupil of Oppolzer, presented a paper on the periodic comet of Winnecke. He found no indication of any influence on the comet's motion due to a resisting medium.

Dr. Spörer presented an historical study of sun-spots. He found, amongst other facts, that between 1650 and 1713 there were almost no spots on the Sun, and that the few which made their appearance were in the southern hemisphere. Further, that the presence of two groups at the same time, one near the right limb and the other near the left, was of very rare occurrence.

In the balloting for the place on the Council made vacant by the death of Prof. Oppolzer, Prof. O. Struve secured 22 votes and Prof. E. C. Pickering 19, so that Prof. O. Struve was declared duly elected.

At the opening of the third sitting, Dr. Krueger announced that he had received a letter from Dr. Holetschek, which stated that the comet discovered by Brooks on August 24 was identical with the long-expected Olbers' comet.

Prof. C. H. F. Peters, in speaking of his photometrical work on small planets, gave the following results:—

	Magnitude.	Volume.
Vesta	6·47 ± 0·04	32·21 ± 1·18
Ceres	7·71 ± 0·05	21·83 ± 1·51
Pallas	8·55 ± 0·02	6·41 ± 0·18
Hygeia	......	4·25

	Volume.
Eunomia	4·25
Juno	3·70
Hebe	2·43
Iris	2·43
Psyche	2·13
Lutetia	1·85

the volume being expressed in millions of cubic kilometres.

The total volume of the ten largest asteroids, therefore, is 81·49 millions of cubic kilometres; that of the first seventy he found to be 127·74, and as the volume of the Earth is 1082841 millions of cubic kilometres, the combined volumes of the first seventy asteroids is to that of the Earth as 1 to 7862.

Prof. Oudemans remarked concerning the problem of determining the relation between the radius of the Epicycle to that of the Deferent (known in Germany as the problem of Pothenot), that it had already been solved by Ptolemy in the 4th Book of the 'Almagest.'

Airy's Numerical Lunar Theory[*].

Au mois de janvier 1874, sir G.-B. Airy annonçait à la Société astronomique qu'il avait entrepris l'exécution d'une théorie de la Lune d'un nouveau genre, fondée non plus sur l'intégration progressive des équations différentielles du mouvement troublé, mais construite *a posteriori*, en substituant dans les équations différentielles les expressions numériques des coordonnées fournies par la théorie de Delaunay, et en cherchant ce qui reste à faire pour les vérifier. En d'autres termes, l'Astronome royal se proposait de faire la preuve des calculs de Delaunay, et d'en corriger, au besoin, les résultats.

Jusqu'ici, les géomètres qui, depuis Newton, ont abordé ce difficile sujet, Clairaut, Laplace, Damoiseau, Plana, Lubbock, Hansen, Delaunay, avaient toujours commencé la théorie *ab ovo*, pour la pousser ensuite aussi loin que possible par le développement progressif des formules fondamentales. Cependant, à mesure que s'élevait l'ordre des termes dont on voulait encore tenir compte, on avait vu la somme de travail, nécessaire pour mener à bonne fin les calculs, augmenter dans une mesure effrayante. Déjà Plana disait à M. Airy: "Quelquefois, Monsieur, ces calculs me font presque perdre la tête!" Les deux volumes de l'Ouvrage inachevé de M. Delaunay représentent 1812 pages in-quarto. En même temps, la succession des termes étant réglée, non par la grandeur numérique des coefficients, mais par leur ordre algébrique, la convergence des séries restait souvent douteuse, ou du moins trop lente, et il fallait parfois les compléter au jugé, en supposant une loi de décroissance, pour en finir. M. Airy a pensé qu'il serrait possible de vérifier l'exactitude des ces résultats théoriques en

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[*] Reprinted from the 'Bulletin Astronomique,' for July 1887.

faisant usage d'un procédé plus expéditif, qui consiste à introduire directement les valeurs numériques des coefficients.

Laissant de côté la théorie de Hansen, dont la forme insolite et quelque peu artificielle se prête mal aux vérifications, M. Airy va droit à celle de Delaunay. Partant des expressions finales, trouvées par Delaunay pour la longitude, la latitude et la parallaxe de la Lune, il ajoute aux coefficients des corrections inconnues (*symbolical corrections*), qu'il suppose assez petites pour qu'on puisse en négliger les produits et les puissances d'un ordre supérieur au premier.

Les nombres ainsi préparés sont substitués dans les trois équations différentielles de mouvement de la Lune, où le temps est pris pour variable indépendante. Ces équations sont celles qui déterminent : 1° le rayon vecteur de la Lune, projecté sur l'écliptique ($\rho = r\cos l$) ; 2° le mouvement aréolaire dans l'écliptique $\left(\rho^2\frac{dv}{dt}\right)$; enfin 3° l'ordonnée perpendiculaire ($z = r\sin l$). Ce sont, dans le Mémoire, les équations fondamentales (10), (11), (12). En les simplifiant un peu, nous pourrions les écrire sous cette forme

$$(10) \quad \ldots\ldots \quad \frac{d^2\rho}{dt^2} - \rho\left(\frac{dv}{dt}\right)^2 + M\frac{a^3}{r^3}\rho = R,$$

$$(11) \quad \ldots\ldots \quad \frac{d}{dt}\left(\rho^2\frac{dv}{dt}\right) = \rho T,$$

$$(12) \quad \ldots\ldots \quad \frac{d^2z}{dt^2} + M\frac{a^3}{r^3}z = Z,$$

où R, T, Z sont les trois composantes rectangulaires de la force perturbatrice, dont la première (la force radiale) est parallèle à ρ, la seconde (la force transversale) perpendiculaire à ρ dans l'ecliptique, la troisième parallèle à z. Il n'y a à considérer ici, pour le moment, que la force perturbatrice qui émane du Soleil. Nous parlerons plus loin de la définition du facteur M.

On calcule séparément, pour les égaler ensuite, les forces accélératrices (*orbital side*) et les forces d'attraction (*gravitational side*) ; les détails des calculs sont contenus dans une suite de Tableaux. On les a toujours poussés au moins jusqu'à la 7^e décimale de l'unité de longueur (0,0000001 = 0″,02) ; tous les nombres sont donnés en unités de la 7^e décimale.

La série de Delaunay qui fournit $\frac{1}{r}$ ou la parallaxe équatoriale a été préalablement divisée par 3422″,7 ; elle a dès lors pour premier terme 1,0000000, et représente le rapport $\frac{a}{r}$. On a formé ensuite les cinq premières puissances de la différence $\left(\frac{a}{r} - 1\right)$, qui ont servi à calculer $\left(\frac{a}{r}\right)^2$, $\frac{r}{a}$, $\left(\frac{r}{a}\right)^2$.

Nous devons faire, à ce sujet, deux remarques. Il est clair, d'abord, que la constante a n'est point la distance moyenne, que nous désignerons ici par a. En se reportant à la série de Delaunay (t. II, p. 802 et 914), on trouve que le premier terme de $\frac{\mathrm{a}}{r}$ a pour valeur

$$1+0,16241\,.\,m^2=1,0009087,$$

où m est le rapport des moyens mouvements. Le premier terme de $\frac{a}{r}$ étant l'unité, on a évidemment $\frac{\mathrm{a}}{a}=1,0009087$. D'après M. Airy (p. 11), on aurait $\frac{\mathrm{a}}{a}=1,0015647$, parce que ce nombre est le premier terme de $\frac{r}{a}$; mais il s'ensuit seulement que $1,0015647\,.\,a$ est une valeur moyenne de r, qui n'est pas nécessairement le demi grand axe (c'est-à-dire la constante définie par la relation $n^2\mathrm{a}^3=\mu$).

Il faut dire ensuite qu'en réalité la série de Delaunay ne représente pas la parallaxe elle-même, mais bien sin P, multiplié par le facteur constant 1,00005 pour que le premier terme devienne égal à 3422",7 (au lieu de 3422",54). C'est ce que Delaunay remarque expressément dans la note de la page 914. M. Airy a cru qu'elle représentait P, et, pour en tirer $\frac{1}{r}=\sin \mathrm{P}$, il a diminué les coefficients des cosinus d'un dix-millième de leur valeur. Ses coefficients sont, par conséquent, trop faibles : celui de $\cos l$ est devenu 0,054509543, au lieu de 0,054514564; celui de $\cos(2\mathrm{D}-l)$, 0,009998132, au lieu de 0,0099822235; celui de $\cos 2\,\mathrm{D}$, 0,0082320, au lieu de 0,0082329, et ainsi de suite.

La série qui fournit la latitude l en secondes a été également exprimée en unités linéaires, en multipliant les coefficients par sin 1", et elle a servi à calculer sin l, cos l, etc. Puis on a transformé d'une manière analogue la série qui fournit la longitude v, et l'on a calculé $\frac{dv}{dt}$ en tenant compte de la composition des arguments des termes successifs.

Ces arguments sont des combinaisons de multiples des quatre angles suivants :

$\mathrm{D}=0,9251987\,.\,t$, distance moyenne de la Lune au Soleil,
$f=1,0040219\,.\,t$, argument moyen de la latitude de la Lune,
$l=0,9915480\,.\,t$, anomalie moyenne de la Lune,
$\mathrm{S}=0,0748006\,.\,t$, anomalie moyenne du Soleil,

où f, S remplacent les lettres F, l' de Delaunay ; on a laissé de côté les constantes qui s'ajoutent aux angles proportionnels à t. Comme unité de t, M. Airy adopte le temps dans lequel la Lune parcourt l'arc 1 : c'est le mois sidéral divisé par 2π, ou à très peu près $\frac{1}{84}$ de l'année julienne. Il s'ensuit que le moyen mouvement $n=1$. L'ordre de succession des termes de la parallaxe et de la latitude est déterminé par la grandeur des coefficients ; les termes de la longitude sont rangés dans le même ordre que ceux de la parallaxe. On a ainsi, par exemple :

Numéro d'ordre.	Argument.	Mouvement.	Coefficient du cos		
			$\frac{a}{r}$	$\left(\frac{a}{r}-1\right)^2.$	$\left(\frac{a}{r}\right)^2.$
1.	0	……	+1,0000000	+15746,25	+10015746,3
2.	l	+0,9915480	+ 545095.43	+ 2520,74	+ 1092711,6
3.	$2D-l$	+0,8588494	+ 99813,2	+ 4492,4	+ 204118,8
4.	$2D$	+1,8503974	+ 82320	+ 5947	+ 170587

Pour la latitude, les termes sont numérotés à partir de 301 (argument f).

Les mouvements des arguments ont été tirés des Tables de Damoiseau. On aurait pu les déduire des expressions que Delaunay a donnés (t. II, p. 237) pour les trois rapports $\frac{dl}{dt}, \frac{dg}{dt}, \frac{dh}{dt}$. Avant la mise en nombres de ces formules, il fait transformer les éléments a, e, γ suivant les indications des pages 799–800, pour que le coefficient du temps dans la longitude moyenne $(g+h+l)$ devienne égal à n. Cela revient, en définitive, à remplacer n, e, γ par $1{,}0052840 . n$; $0{,}999425 . e$; $1{,}002365 . \gamma$, avant d'attribuer aux éléments les valeurs numériques adoptées par Delaunay. En exécutant ce calcul, assez laborieux, j'ai trouvé

$$\frac{dg}{dt}=0{,}0124593 . n\,; \quad \frac{dh}{dt}=-0{,}0040211 . n\,; \quad \frac{dl}{dt}=0{,}9915621 . n.$$

La somme devient $1{,}0000003 . n$. Les termes inconnus du 8^e^ ordre pourraient encore modifier la 5^e^ décimale du dernier de ces nombres. D'après la loi de décroissance des termes, qui convergent lentement, il est à présumer que les nombres définitifs deviendront

$$0{,}0124744\,; \quad 0{,}0040211\,; \quad 0{,}9915467.$$

Les colonnes 1 à 29 des Tableaux de la Section II renferment les détails du calcul des accélérations (*orbital quantities*), telles que

$$\frac{1}{2}\frac{d^2}{dt^2}\left(\frac{r}{a}\cos l\right)^2, \quad \frac{d}{dt}\left[\left(\frac{r}{a}\cos l\right)^2\frac{dv}{dt}\right], \quad \frac{d^2}{dt^2}\left(\frac{r}{a}\sin l\right), \; \ldots .$$

qui figurent dans les trois équations (10), (11), (12), et en forment la partie cinématique.

La Section III (colonnes 31, 32) contient les expressions des deux composantes de l'attraction qui a lieu entre la Terre et la Lune, composantes qui entrent dans les équations (10) et (12). Elles sont affectées du facteur $\mathrm{M}=\frac{\epsilon+\mu}{a^3}$, où ϵ, μ sont les masses des deux corps célestes ; ce facteur, qui ne diffère pas beaucoup de l'unité, reste provisoirement indéterminé. M. Airy montre (p. 11) qu'il a pour valeur approchée

$$1+\frac{1}{2}m^2=1{,}0027976,$$

où m est le moyen mouvement du Soleil en faisant $n=1$. Or les valeurs réduites des coordonnées de Delaunay supposent essentiellement (p. 799) que

$$\frac{\epsilon+\mu}{\mathrm{a}^3}=n^2\,;$$

ce rapport est donc égal à l'unité. Nous avons, d'autre part, comme on l'a déjà dit,

$$\frac{\mathrm{a}}{a}=1{,}0009087,$$

d'après la définition de la constante a ; par conséquent,

$$\mathrm{M}=\left(\frac{\mathrm{a}}{a}\right)^3=1{,}002728.$$

Ce nombre résulte directement de la théorie, et il ne semble pas qu'on puisse le modifier. C'est d'ailleurs, à très peu près, le même que M. Airy déduit (p. 76) des termes constants de l'équation (10).

La Section IV est consacrée au calcul des composantes de la gravitation solaire, qui figurent dans les trois équations du mouvement (colonnes 32–72). Dans la Section V, M. Airy explique comment les calculs numériques des Sections précédentes ont été vérifiés, et indique certaines modifications qui ne portent que sur les dernières décimales.

Dans la Section VI, on procède d'abord à une détermination provisoire du facteur M. Les résultats fournis, à cet égard, par les principaux arguments sont loin d'être concordants. Voici, par exemple, les trois déterminations de M que l'on trouve rapportées à la page 76 :

Arg.	Accélér.	Gravit. ⊕ − ☾.	Grav. ⊙	M.
1......	−9960060	=−9959740.M	+26830	1,002726
2......	− 549570	=− 542808.M	− 5661	1,002021
301......	− 902822	=− 895367.M	− 5013	1,002721

Comme on le voit, la valeur de M fournie par l'argument 2 est plus faible que les deux valeurs concordantes fournies par les arguments 1 et 301. M. Airy avoue que ce désaccord lui a causé beaucoup de trouble : le calcul a été répété trois fois, mais l'on a toujours retrouvé les mêmes nombres. D'autres arguments donneraient des écarts encore plus sensibles. Adoptant alors la valeur

$$M = 1{,}0027250 + \delta M,$$

M. Airy forme les résidus relatifs aux divers arguments, pour les trois équations fondamentales (colonnes 74, 75 et 77). On a ainsi, par exemple,

Arg.	Résidus de l'équation (10).		Résid. de l'equ. (11).
1..........	$-\ 5{,}6$	$+.9960 . \delta M$	....
2..........	$+\ 360$	$+.0543 . \delta M$	$+\ 192{,}7$
3..........	$-\ 1563{,}4$	$+.0099 . \delta M$	$-\ 725{,}9$
4..........	$-\ 911$	$+.0085 . \delta M$	$-\ 523$
5..........	$+\ 607{,}3$	$+.0030 . \delta M$	$+\ 345{,}2$
14..........	-2774	$+.0002 . \delta M$	-1494
22..........	-2833	$+.0001 . \delta M$	-1334

Les résidus sont beaucoup plus petits pour l'équation (12), qui détermine la latitude ; mais pour l'équation (10), notamment, ils sont considérables.

Disons tout de suite que ces discordances n'ont rien d'imprévu, et qu'il est facile de les expliquer. On sait, en effet, que Delaunay n'a poussé le développement de $\frac{1}{r}$ que jusqu'aux termes du 5^e ordre. En remontant aux opérations qui ont fourni ces termes, on peut se convaincre que les termes du 6^e ordre, omis dans l'expression de la parallaxe, représentent dans certains cas une fraction notable (0,3 ou 0,4) de ceux du 5^e, et qu'il en résulte pour les coefficients des corrections pouvant dépasser $0'',10$, ou 300 unités de la 7^e décimale. Pour citer un exemple, la 4^e opération de Delaunay introduirait dans le coefficient de $\cos l$ le terme $-216\ em^5$, qui vaut $0'',10$, ou plus du tiers du terme en em^4 fourni par la même opération. D'après la loi de décroissance des termes analogues, il est fort possible que le coefficient de $\cos l$ doive être complété par une terme tel que $-\ 110\ em^5$, qui vaut $0'',05$ ou 150 unités. Le coefficient g_2 de M. Airy, qui était trop faible de 50 unités, devrait alors être diminué encore de 100 unités, et réduit à 0,0545000 ; or, c'est précisément la correction que M. Airy tire des résidus des équations (10) et (11), relatifs à l'argument 2. Il en est de même pour le coefficient g_3 de $\cos(2D-l)$, qui devra probablement être augmenté de $0'',14$, ou de 400 unités de la 7^e décimale, à cause des termes du 6^e ordre fournis par la 41^e opération ; et c'est ainsi que s'explique la correction $\delta g_3 = +425$ que trouve M. Airy. On le voit, les résidus des trois équations différentielles fournissent le moyen d'évaleur, d'une manière indirecte, les termes du 6^e ordre,

négligés par Delaunay dans le calcul de la parallaxe, et de compléter ainsi sa théorie, en supposant toutefois qu'il n'existe aucune erreur dans les coefficients de la longitude et de la latitude, dont le développement a été poussé beaucoup plus loin. Mais il faudrait vérifier avec soin l'expression de $\left(\frac{r}{a}\right)^2$ obtenue par M. Airy, sur laquelle repose en partie cette détermination.

R. Radau.

[To be continued.]

Account of further Observations of the Lunar Crater Plato in the years 1882–84.

The Streaks.

An account of the observations of the spots upon the floor of Plato, made in the period comprised between March 1882 and February 1884, or, as it has been termed, the "Second Period," has already been given, and will be found in the 'Observatory' for January 1887. It is now proposed to consider, in a somewhat similar manner, the light streaks and markings visible upon the nearly level surface which forms the floor of Plato. These features, it is to be regretted, have not in former times received so much attention as the white spots, nor as in fact they deserve, and comparisons made between their present forms and brightnesses and those which they possessed at the time of previous systematic observations of Plato will often, for this reason, prove far from satisfactory. It is more especially with reference to the brightness of the streaks that the earlier results fail us. The visibilities of these objects for the period 1869–71 do not appear to have ever been calculated in the same manner as those of the spots, if indeed the observations and drawings were sufficiently numerous and circumstantial to permit of this being done in an accurate manner. In the First Period they were not so; and although a table of the mean visibilities for that time has indeed been formed (see 'Observatory,' 1883, p. 90), the results there given can only be regarded as approximate. It is a matter of more particular regret that such is the case, since it would seem that the light-streaks are better adapted for the purpose required, and capable of giving more accurate results than the spots, chiefly no doubt from the circumstance that, whilst the latter are mostly very minute, the former extend over a considerable area; and their visibility is therefore less liable to be affected by changes in the atmospherical and other conditions under which the observations are made. It is found in practice that, with the exception of a few of the smaller and more delicate objects, the light-streaks are seen with nearly the same ease and distinctness under very varied atmospherical conditions, and that only when definition is extremely confused does their observation become difficult or uncertain, whilst it is otherwise with respect to the white spots. Although, however, comparison with the previous observations is thus often far from being satisfactory, it is hoped that the results of the Period now under consideration may at least serve to fix, for that time, in a more exact manner than has hitherto been attempted, the forms and brightnesses of the various light-streaks, with which future observations may be more satisfactorily compared.

Reference has been made to the more exact method of recording the brightnesses of the spots now in use *. The same principle was likewise naturally extended to the case of the streaks, and the *mean visibilities* of the streaks in the Second Period should therefore have a high degree of accuracy, greater indeed, for the reason already indicated, than in the case of the spots. These *mean visibilities* are embodied in the Table following; the *sector*, *b*, near its middle, or more exactly where it is crossed by the streak *p*, being assumed as unity, in the same manner as the spot No. 1 in the case of the spots.

Some of the streaks are very far from being of equal brightness throughout their whole extent, and the designations given in the Table have there the following restricted significance:—*b* refers to that part of the *sector*, as the large fan-shaped marking on the south-eastern portion of the floor is termed, crossed by the streak *p*, or lying immediately north of spot 24 and between Nos. 6 and 17; *e* designates that portion of the streak which is immediately adjacent to the border, the more eastern part being much fainter; ϵ refers to the more southern part of the marking only; η specifies that portion of the streak lying to the north-east of spot No. 7, the remaining part extending from that spot to No. 4 being much fainter than the rest; e^2 has reference only to the portion lying between spots 17 and 26.

TABLE OF THE MEAN VISIBILITIES OF THE STREAKS.

Streak.	Mean Visibility.	Streak.	Mean Visibility.	Streak.	Mean Visibility.
b ..	1·000	β ..	·402	c^2 ..	·003
c ..	·408	γ ..	·772	d^2 ..	·408
d ..	·003	ϵ ..	·614	e^2 ..	·323
e ..	·494	ζ ..	·652	f^2 ..	·079
i ..	·598	η ..	·582	g^2 ..	·136
l ..	·025	κ ..	·348	h^2 ..	·035
n ..	·199	ν ..	·012	W	·082
p ..	·506	a^2 ..	·028	X ..	·003
a . o	·563	b^2 ..	·206	Y ..	·009

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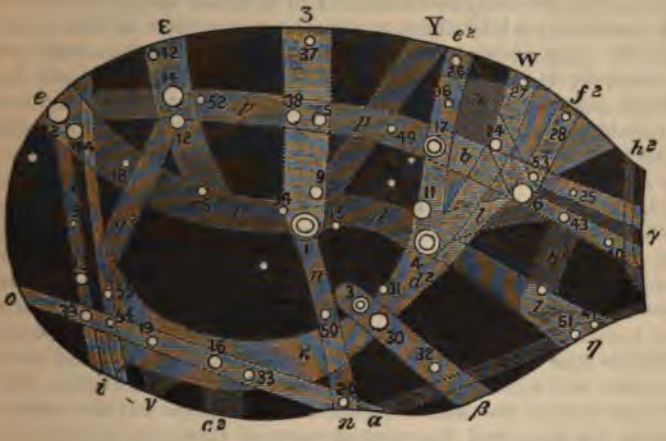
* 'Observatory,' January 1887, p. 64.

The light-streaks seen in the Second Period (27 in number) are, together with the white spots, shown upon the accompanying chart of Plato. This chart has been constructed with considerable care from the numerous drawings and sketches, and is believed to be well representative of the general appearance of the interior of Plato during the Second Period. Its construction was facilitated by the enlargement, in the first place, of all the drawings to the same scale, and care was taken by avoiding the sight, during its construction, of any former drawings or maps of the markings, and other precautions to avoid as much as possible the influence of bias. Some attempt has also been made to represent the relative brightness of the various markings.

PLATO. Second Period.



○ =White spots. ◎ =Spots seen as crater-cones.

All the streaks seen in the First Period were reobserved in the Second, and eight additional streaks have also been noted in the latter period, namely—*d* and *l* (both old streaks), e^2, f^2, h^2, W, X, and Y. Of these additional streaks, W, X, Y, probably e^2 and possibly f^2 were discovered by Mr. H. Pratt in 1873–74; h^2 was first detected by Mr. T. P. Gray on Oct. 25, 1882.

In proceeding to the consideration of some of the more considerable and remarkable differences which seem to have occurred in the distribution of the light markings upon the floor, it is essential to bear in mind that many of these objects are of a very delicate nature and sometimes of rather ill-defined extent, so that personal peculiarities of the observers and differences in the instrumental means employed must influence to a large extent the descriptions and drawings; so that in comparing these, especially when they have been made by different observers, it is necessary to take as many precautions almost as in comparisons of descriptions and drawings of the nebulæ. Nevertheless, differences which can be ascribed to these causes must necessarily have a limit. Apparent changes due to differences of libration may, in a long series of observations, generally be considered to be either absent or reduced to a minimum; whilst those produced by variations in the conditions of seeing are, as has already been pointed out, of small consequence in the case of streaks, except for the very faint and delicate ones. These remarks being first premised, it will be well to consider some of the more remarkable light-streaks in some detail.

The Sector, *b*. This is the brightest and most considerable of all the light markings upon the floor. Its apparent structure during the Second Period was of a somewhat highly complicated nature, and, as will be seen by reference to the accompanying chart, its surface was seen traversed by various light-streaks. Two of these must be regarded with unusual interest. Beer and Mädler, as is well known, in the first edition of their 'Mappa Selenographica,' delineate four light-streaks crossing the floor in a north and south direction, and likewise mention them in their 'Der Mond.' Two of these streaks are shown rather close together on the eastern part of the floor, and the most western of these two corresponds exactly in position, at least as regards its southern half, with the streak marked e^2 in the present chart of Plato; whilst the southern half of the easternmost streak would likewise be represented satisfactorily by the modern one distinguished as W. Streak W was observed by Mr. Pratt in 1873–4, and so probably was e^2, but they were neither of them seen in the course of the systematic survey of 1869–71. The recovery in recent years of the southern portions of these two ancient streaks renders it somewhat difficult to conceive how objects seen and drawn by Beer and Mädler with their comparatively small instrumental means, and which must thus evidently have been of a rather conspicuous character, could have escaped the notice of the small army of observers, provided with instruments of various sizes and powers, who so closely scrutinized the interior of Plato in the course of the years 1869–71, and with, of course, a knowledge of the existence of the features in question, if they had at that time been of an equal degree of plainness. Moreover only the southern parts of these two old streaks have been reobserved in recent years, the northern portions still remaining invisible, though the continuation of the most western of the two streaks is doubtless represented in part by d^2. It will be necessary to return again to the subject of these streaks of Beer and Mädler *. It may be added that e^2 has during the last two or three years been almost constantly visible, even with a telescope of only $2\frac{3}{4}$-in. aperture.

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* For the appearance of the *Sector* in the First Period, see the 'Observatory,' 1883, p. 112. The dark rifts there referred to were seen again in the Second Period.

Streak c. Under favourable circumstances, this has been seen to consist of two narrow and nearly parallel streaks lying close together, the components being about equally plain and bright.

The Trident was only seen complete on one occasion, although it was frequently observed entire with the single exception of the stem *d*. The eastern part of the branch *e* is usually faint. The branch ζ, one of the plainer streaks upon the floor, corresponds exactly in position with the southern portion of another of the streaks noted by Beer and Mädler, though here again, like the two already referred to, the northern part of the old streak still remains invisible. The object *n* could scarcely be the continuation of it.

Streak l is an object, the existence of which has been doubted. It has, however, been seen recently upon several occasions curving round from spot No. 4 into the bright streak γ, and it has even been observed as bright as the last-named feature, although, as much of it lies on the bright ground of the *Sector*, it was never very conspicuous.

Streak p. This feature, with reference to which there is strong probability of a change of brightness, if not in extent, has not differed essentially in appearance and brightness since the First Period. It seems to be now established with some degree of certainty, that some of the light markings upon the floor undergo in long intervals of time considerable changes of brightness, and the early observations of Plato are not sufficiently numerous or exact to determine whether its present conspicuous character is due to the brightening up of an old streak or the formation of a new one.

Streaks α, *o*, and κ. In the First Period these three streaks were considered together, but the designation of κ is now confined to the light marking extending from spot No. 3 to No. 16. The portion of this streak represented parallel to α, *o* has quite recently been discovered to be due principally to an old streak μ and an extension of the same eastwards, and which the optical means formerly employed were probably insufficient to resolve clearly. The form of this marking κ parallel to α, *o* as represented in the present map of the floor, and also in those on p. 87 of the 'Observatory' for 1883, and p. 247 of the British Association Report for 1872 respectively, must therefore be considered to be in great measure a deceptive appearance *. Similar instances of erroneous delineation of markings due to the optical means employed being insufficient for their proper resolution are by no means rare in delicate observations of this nature, and must be carefully guarded against.

Streak γ has, under favourable circumstances, appeared to consist actually of two nearly parallel light-streaks lying close together.

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* A drawing showing the true appearance presented by the streaks α, *o*, κ, and μ will be found in the 'English Mechanic,' vol. xliv. p. 499.

Streak η. That part which lies between spots Nos. 4 and 7 is very much fainter than the rest, the line of demarcation between the brighter and fainter portions being sharply marked.

Streak b^2 was almost constantly observed, even under unfavourable circumstances, and has generally appeared about as bright as the old streak n, which has been known to us ever since 1860. It does not seem, however, to have been seen prior to Jan. 12, 1881, on which date it was partially delineated by Mr. Gray.

Streak g^2. Three of the streaks shown by Beer and Mädler have already been identified, at any rate in part. The fourth remaining streak of these selenographers is clearly identical with that now known as g^2, in combination with the southern portion of ϵ and i. The history of this feature becomes then a curious one. First seen by Beer and Mädler about fifty years ago as a broad and, it may be inferred, conspicuous light-streak, it has apparently escaped the notice of all observers, including those who took part in the exhaustive examination of the floor in 1869–71, since that time until the 1st November 1873, on which date it was re-discovered by Mr. H. Pratt. The marking was again seen in the course of the observations of 1879–82, and in the Second Period it was usually observed at any time from near sunrise on Plato until shortly before sunset, and thus under very varied conditions of libration and illumination, so that its mean visibility rose to ·136. It is worthy of note that in this last Period the streak was always delineated as a rather narrow one. In the Third Period of observations, recently brought to a termination, not only was the object almost invariably seen, but it has generally been both delineated and described as being much broader than before, and so in fact to be broader than the streak c, with which latter object it has been frequently compared and considered equal in plainness, the somewhat greater width of g^2 making up for a less degree of actual brilliancy. There has then been much resemblance to the representation of the same feature in the 'Mappa Selenographica.' Quite recently g^2 has been discovered to be really double, and to consist of two rather narrow parallel streaks of about equal plainness, a circumstance which might account for the changes noticed in the breadth of the marking. After making every possible allowance for personal equation, the only thing which in the case of this feature could well have any appreciable influence, it seems scarcely possible to avoid the conclusion that there have been considerable real changes in the brightness of this light-streak.

In addition to the white spots and light-streaks, some curious *dark* patches or streaks have been observed upon the floor, and these seem deserving of careful attention, their nature being far from obvious. The most frequently visible and conspicuous of these objects is situate at the extreme north-eastern corner of the floor. The surface just at this part has not infrequently been observed to be intensely dark, almost black in fact. A second occurs north of the streak a, o, between n and ν. Lastly, on one occasion a very narrow, nearly black, thread-like streak was seen at the extreme south border, extending from ζ to f^2, and cutting off the extremities of the streaks in its passage. These dark surfaces are situate at about the lowest portions of the floor of Plato, which, as is well known, is slightly convex.

West Brighton,
1887, 21st September.

A. STANLEY WILLIAMS.

Meteor Notes.

THE clear skies of the past summer enabled me to secure more observations than during the same period in any previous year. For the three months, June, July, and August, the summary of results for 1887 stands as follows:—

Month.	Nights of obs.	Hours of watching.	Meteors seen.	Meteors registered.	Radiants found.
June	18	42	196	174	15
July	14	36¼	340	293	27
August ..	16	45½	400	322	34
3 months .	48	123¾	936	789	76

Fourteen of the radiants were of the Perseids, derived from single night's observations for the purpose of tracing the displacement in its position.

I have already briefly alluded to my results up to Aug. 14 ('Observatory,' Sept. p. 315). On the six nights from Aug. 20 to 25 inclusive, I observed 193 meteors in 24 hours of watching. The paths of the meteors registered give evidence of a very large number of streams, and do not indicate any showers of special activity. I have selected the following 12 positions, which are very sharply defined, from the observations:—

No.	Date, 1887.	Radiant. ° °	Notes and Comparisons.
1...	Aug. 14–24	5 +54	Swift; streaks. Near α Cassiopeiæ.
2...	Aug. 20–25	43 +39	Swift; streaks. Heis, 45° +40°, Sept. 1–13.
3...	Aug. 20–24	54 +71½	Very swift; streaks. G. & H., 50° +75°, Sept.
4...	Aug. 21–24	60 +50	Very swift; streaks. D., 61° +50°, Aug. 21–23, 1879.
5...	Aug. 7–22	73 +41	Very swift; streaks. T., 75° +45°, Aug. 29, 1870.
6...	Aug. 10–24	135 +78	Swift. Weiss, 131° +78, Aug. 11–12, 1879.
7...	Aug. 20–22	242 +49	Very slow. D., 243° +48°, Sept. 3–4, 1885.
8...	Aug. 14–23	264 +62	Slow; bright. T., 264° +64°, Aug. 20–25, 1871.
9...	Aug. 7–23	327 +48	Slow. Lacertids.
10...	Aug. 6–25	334 +58	Rather slow. Seen also in June and July.
11...	Aug. 20–24	347 +15	Swift. Sawyer, 348° +17°, Aug. 28–Sept. 2, 1880.
12...	Aug. 10–25	349 +49	Swift. D., 350° +47°, Aug. 23, 1879.

No. 9, at 327° +48°, is different to the July Lacertids at 335° +49° (see 'Observatory,' Sept. 1887, p. 314). No. 11, E. of α Pegasi, is identical in position with the radiant of the large fire-ball of Sept. 7, 1875, which Col. Tupman placed at 347° +15°.

The Draconids (No. 8) are from a radiant-point which is apparently persistent during the greater part of the year. I have distinguished it as follows:—

Jan. 19–25, 1887 ..	261°	+63°	July 9–13, 1885	266°	+63°
Mar. 28, 1887	263	+62	July 27–Aug. 2, 1887	263	+61
April 17–25, 1887 ..	260	+62	July 29, 1880	257	+64
April 20–22, 1878 ..	263	+62	Aug. 14–23, 1887 ..	264	+62
Apr. 30–May 9, 1886	264	+64	Aug. 31–Sept. 7, 1877	260	+63
May 11–14, 1885 ..	262	+64	Oct. 5–12, 1885	262	+64
May 28–30, 1886 ..	264	+64	Nov. 7–10, 1877	256	+64
June 13, 1885	262	+64			

Decided traces of it have also been observed at other epochs, but the meteors were not sufficiently numerous to give good radiants. The mean of the 15 above positions is at 261°·8 +63°·1. There are showers near it at 254° +56° in the earlier part of the year, and at 261° +69° in July and August. This radiant has recently furnished some brilliant meteors, one of which was recorded both at Bristol and Leeds on August 21 at $11^{h}\ 2^{m}$. At the latter place it was seen by Mr. D. Booth, who is making numerous observations for the Meteoric Section of the Liverpool Astronomical Society. The meteor was estimated as equal to Venus, both at Bristol and Leeds; but though its *direction* was probably recorded with considerable exactness, the *positions* of the beginning and end points are not in satisfactory agreement, the Leeds observation placing the height much less than that at Bristol. The mean of the two gives 80 miles for the beginning over a point 6 miles E. of Aberystwith to 45 miles above a place 7 miles W. of Rhayader; Earth-point near Hay, Herefordshire; radiant 264° +61°. It would be important to hear of observations of this meteor from the Midlands, from Wales, and the S.E. coast of Ireland.

This year, on Aug. 14, I found the Great Perseid radiant very definitely centred at 53° +57° from 8 tracks. This position is well confirmed by a doubly observed meteor seen on that night, as follows:—

Hour.	Mag.	Path		Observer.
		From	To	
h m				
13 46	4	15° + 4°	9½° −10°	D. Booth, Leeds.
13 47	3	58½ +41½	59½ +37¼	W. F. D., Bristol.

At Bristol this meteor appears to have been seen earlier in its flight than at Leeds; but both stations indicate the height at its commencement as more than 110 miles, which is rather unusual, though instances of even greater elevation in the Perseids are not wanting. From the combined observations the meteor when first seen was some 125 miles above a point near Braintree, and at disappearance the height was 87 miles near Enfield. Earth-point near Basingstoke, in Hampshire.

In 1879, between Aug. 21 and 25, I saw a fine display of 56 meteors from a radiant at 291° +60° ('Observatory,' Vol. iii. p. 172). I carefully looked for this shower again in 1884, 1885, and 1886, but without recovering it. This year also, though I made lengthy observations at the right epoch, has resulted in a comparative failure; for of the 193 meteors I recorded between Aug. 20–25, certainly not more than 5 can be ascribed to the very active radiant seen in 1879. The shower is evidently a periodical one and probably of some importance, so that observations should be resumed every year until its reappearance.

On the morning of August 31 last, during a clear interval between heavy storms ($14^h\,15^m$ to $15^h\,45^m$), I saw 12 meteors several of which belonged to a radiant at about 46° +43°. One of these, appearing at $14^h\,25^m$, was as bright as Venus, and left a fine broken streak in its path from 19° +27° to 5° +14°.

Were there more observers, instances of multiple observations of large meteors and ordinary shooting-stars must be frequently obtained, and in a short time valuable evidence would be collected as to the displacements of radiants like the Perseids, and as to the apparently stationary aspect of other showers similar to the Draconids mentioned above. To be really useful such materials must necessarily be very exact. Prof. Herschel has most aptly remarked that "the highest attainable accuracy in mapping the observed directions of the apparent paths of shooting-stars is the real key to the solution of the problem presented by their nightly flights" (B.A. report on Luminous Meteors, 1878). The number of showers is so very great, and individually they are nearly all so attenuated, that it is impossible either to fix their positions or learn their characteristics unless the observer is extremely careful, precise, and discriminating in his work. It is probable that no two meteor-streams are exactly alike (though the more ancient ones are probably somewhat similar as regards tenuity and long duration), and they seem as numerous as the stars themselves. Attempts to condense the mass of existing materials cannot be successful until the duration of meteor-showers has been more thoroughly investigated. To average numbers of different showers, as was done in the B.A. Catalogue of 1876, is simply to sacrifice accuracy for brevity. More observers and greater precision will finally dispel much of the confusion in which this interesting branch of Astronomy is involved. W. F. Denning.

Bristol.

Selenographical Notes.

Rills near Cauchy.—Mädler and Neison agree in showing a considerable cleft (discovered by Lohrmann in 1824) traversing the Mare Tranquillitatis from south-west to north-east and passing on the south-east side of the bright formation Cauchy. Is this object a cleft or a ridge, or a combination of both? In Schmidt's 'Rillen' it is classed as a rill (S. 18), but in his map he represents a long ridge, interrupted in two places by craterlets, on the site; while north of Cauchy he draws a prominent cleft which, originating at a mountain south-west of the formation, and trending for some distance in a north-east direction, bends rather suddenly towards the north and terminates at a point a little west of Vitruvius *c*. This object would almost seem to be an extension of that shown by Neison as commencing among the hills north-east of Taruntius and ending north of Cauchy in lat. 12°, though he represents it as running north of the crater D (Neison, Map 1), while Schmidt's rill certainly passes about midway between this object and Cauchy. However this may be, no trace of this cleft is shown either by Mädler or Neison, where it is now most apparent, though they draw a ridge in the position it occupies. Between 10^{h} and 12^{h} on the 6th September the neighbourhood was favourably observed under evening illumination. In the place of the cleft δ, shown by Mädler and Neison, but drawn by Schmidt as a ridge, were two bright, sharply-defined, white streaks slightly inclined to each other, with a short gap about midway between their extremities. They were bordered on the side opposite the Sun by a narrow band of shadow, and reminded one of the straight wall near Thebit (the so-called "Railway") seen a few hours after sunrise, no trace of a rill being apparent; yet on former occasions, notably at 9^{h} on 3rd May, 1881, and at 9^{h} on 1st June, 1881, when the W. long. of the morning terminator was, in the first case 25° 27′, and in the second 31° 16′, they seemed to consist of two contiguous rills with a narrow intervening gap occupied by a small conical hill. On the latter date the western section exhibited a bifurcation, and the eastern appeared to increase gradually in width and depth in its progress towards the north-east. No indications whatever of the bright narrow wall so prominent on the 6th September were perceived on either evening.

In M. E. Stuyvaert's 'Dessins de la Lune' there is an admirable drawing of Cauchy and its surroundings, made under evening illumination at $14^{h}\ 30^{m}$ B.M.T. on 17th February, 1881, the terminator passing a little west of the formation. Here δ is distinctly shown as a rill with two short branches towards the south near its western end—one of which answers to the bifurcation recorded in my observation June 1st the same year. The break, always very obvious to me, does not appear in his sketch, in which the rill is shown as continuous from end to end, with, however, a sudden swerve at the supposed gap, and as terminating near a group of 5 or 6 craterlets. As regards the cleft north of Cauchy, which Mädler and Neison omit, showing a faintly marked ridge near its site, M. Stuyvaert's drawing agrees as a whole very fairly with my observation on the 6th September, making due allowance for a slight difference in the phase, the west long. of the evening terminator in the one instance being about 39° and in the other 37°; but I observed the following details which he does not record, viz., two elongated low elevations or mounds bordering the south-east flank of the cleft, and a row of three craterlets on the same side, situated about midway between the mounds and Cauchy. The prominent crater which he shows some distance north of the rill was a conspicuous object on the terminator. Cauchy itself was just beyond its limits, the greater portion of the eastern wall being in sunlight, while the opposite rim was only illuminated at one brilliant star-like point, representing a peak. He also observed a little crater south of the formation which, he remarks, is not shown in any map. Schmidt, however, draws a crater on the south slope of Cauchy, which may possibly answer to this object. A second crater, north of the wall or rill, δ, a little east of that seen by M. Stuyvaert, was an easy object on the 6th September. The last-named observer follows the cleft north of Cauchy to a point a little east of the crater north of this formation, which, as just mentioned, was on the terminator at the time of my observation. I was able to trace it in a very attenuated form much farther towards the north-east, to a point not far from Vitruvius *c*.

It is very desirable that observers should turn their attention to this region, with the view to determine the actual character of the object δ and to explain the anomalies just referred to. From the fact that Schmidt represents it in his map as constituting part of a ridge (though he classes it as a rill elsewhere), and as it was seen on the 6th September in the form of two straight, bright, narrow walls, casting a definite shadow without any of the usual characteristics of a cleft, but rather resembling the curious features observed by M. Trouvelot in connection with rills in Eudoxus, and in the neighbourhood of Burg and Aristarchus, termed by him *Murs Enigmatiques*, while under nearly the same illumination M. Stuyvaert saw it as a cleft without any indications of a ridge or of the straight walls, it is clear that we have here a lunar detail which should be carefully examined under every possible angle of illumination.

Kempston, Beds., 1887, Sept. 21. THOS. GWYN ELGER.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Comet discovered by Montaigne and Olbers in 1780.

GENTLEMAN,—

Now that Olbers's periodical comet of 1815 is in view, perhaps a few words may be acceptable respecting the first cometary discovery of that astronomer (made a few days after he had completed his twenty-second year), in which he was anticipated by about half an hour by Montaigne, the first discoverer, in 1772, of the comet afterwards known as Biela's. The comet in question was discovered on the evening of the 18th of October, near the star τ Ophiuchi. In Mr. Chambers's list it is stated that the duration of visibility was "3 days;" but this is an inadvertence, as the three days on which Montaigne observed the comet were not consecutive, but were the 18th, 20th, and 26th of October (the first of these observations was really only an estimation, and the deduced place only an approximation). Messier did not receive news of Montaigne's discovery until the 28th of October; early on the morning of the 27th he had discovered another comet not far from β Leonis, which reckons as Comet I. 1780, because it passed its perihelion at the end of September, whilst Montaigne's was calculated not to arrive at perihelion until the end of November. Unfavourable weather prevented Messier from searching for Montaigne's comet until the 3rd of November, and he never succeeded in seeing it. He suggested that as Montaigne only saw it for a very short time on the 26th of October, he might have mistaken a small star-cluster for it. Olbers, however, pointed out ('Berliner Astronomisches Jahrbuch' for 1804, p. 175) that the cluster in question was a considerable distance (45′ to the east and 1° 15′ to the south) from the place recorded by Montaigne for the comet. He also indicated the accuracy (as much as the circumstances under which they were made would allow) of Montaigne's observations, who had already discovered two comets before (in 1772 and 1774); and although he was mistaken in supposing he had discovered a satellite of Venus which had no real existence, he was not the only astronomer who had been thus deceived by what it is evident was a "ghost." Olbers gives his own observation of Montaigne's comet of 1780 on the 18th of October; and although it is also an estimation, yet the place agrees sufficiently well with that from Montaigne's observation to prove the approximate accuracy of both. He concludes that the reason why others failed to perceive the comet (which probably became somewhat brighter) after the 26th of October, was that the elements of the orbit by which it was sought were determined by Boscovich's constructive method, which was not well adapted to the case of this comet and gave erroneous results for it. Finally, Olbers gives the elements calculated by his own method. These are probably tolerably accurate, and are to be found in most catalogues of comets. They make the motion retrograde; the time of perihelion passage, 1780, November 28; longitude of ascending node, 142° 1′; inclination, 72° 3½′; longitude of perihelion, 246° 52′; log. perihelion distance, 9·712041.

Yours faithfully,

Blackheath, 1887, Sept. 12.

W. T. Lynn.

The Variable Star Algol.

GENTLEMEN,—

I have not seen Mr. Barr's paper referred to in his interesting letter on the above subject, but I think he mistakes either the suggestion of Professor Pickering or the object of the Greenwich observations. Prof. Pickering did not suggest that the spectroscope should be employed as a test of the correctness of the Satellite Hypothesis, but that quantitative spectroscopic measurements should be made for the purpose of determining the parallax of the star and orbit of the satellite on certain assumptions made by him, the Satellite Hypothesis being assumed to be beyond doubt. I doubt the possibility of making quantitative spectroscopic observations with the degree of exactness required for this purpose, conceding the correctness of the Professor's assumptions. But the Greenwich observations, I apprehend, have a different object in view, viz. to ascertain whether there is a satellite at all. Observations of a much less accurate character will suffice to decide this question.

I may remark that the satellite may not be as large (relatively to the principal star) as Professor Pickering and Mr. Maxwell Hall suppose. In the first place, I know of no good photometric measurements of the intensity of the light at maximum and minimum *, and a skilled observer on such subjects tells me that he thinks the diminution of the light of Algol has been generally overrated. But, in the second place, Algol, like the Sun, is probably surrounded by an atmosphere which absorbs part of the light and renders the centre brighter than the edges, inasmuch as the light from the edges reaches us through a greater depth of this absorbent medium. If this be so, it is evident that a satellite passing over the centre of Algol might intercept half the light of the star without covering one half of the star's disc. The light from near the edges of the Sun is redder than that from the centre, owing to selective absorption, and the light of Algol, I believe, also becomes redder at the minimum. This latter feature, however, occurs with so many variable stars, that much stress cannot be laid on it. But the amount of light intercepted is no certain test of the size of the satellite's disc.

Mr. Barr's letter suggests to me an explanation of the shortening of the period of Algol, which Prof. Pickering attributes to a secondary satellite. The shortening of the period since the star was first observed is, according to Prof. Pickering, about 5 or 6 seconds. Now Mr. Barr shows that a velocity of 30 miles per second in the direction of the solar system would render the apparent period shorter than the true one by no less than 40 seconds. It follows that a shortening of the period by 5 or 6 seconds would be accounted for by an *acceleration* of about 5 miles per second in the motion of Algol towards the solar system. According to Prof. Pickering's data, this acceleration must have taken place between the years 1830 and 1850, since which latter date the motion has again become tolerably uniform, but of course at the augmented rate. It would be curious if we were able in this manner to compute the velocity of Algol in the line of sight, at a period long prior to the invention of the spectroscope. In the case of two stars as close together as Algol and his satellite, however, the whole intervening space may be occupied by a resisting medium.

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* [Prof. Pickering has given the results of a series of photometric determinations of the light of Algol in the Proceedings of the American Academy, Vol. xvi. p. 310. The observations were made on 13 nights, at all points of the star's period of variability, and include 230 sets of 12 settings each; or 2748 settings in all.—EDITORS.]

Truly yours,
Dublin, 1887, Sept. 5.
W. H. S. MONCK.

The Determination of Meteor-paths and Radiants.

GENTLEMEN,—

Prof. H. A. Newton, in a paper published in the 'American Journal of Science' for June 1886, refers to "the glancing of meteors on entering the air," and says "this glancing is not confined to the Biela meteors. It was true of the Leonids and still more of the Perseids. It is reasonable to assume that it is true of all shooting-stars. It is not therefore as simple a matter as some have supposed to separate meteors into groups, allotting them to different radiant-points, or to establish the persistency or change of such points. To the uncertainty of the observation of a path which, with the very best observers, amounts to two or three degrees, is to be combined the uncertainty of the amount and direction of its early glancing, which amounts also to several degrees. Besides all this is the uncertainty due to the fact that any point above the horizon in a meteor-path prolonged backward may have been its radiant. Any radiant that has been determined from a small number of paths must be very unreliable."

I submit that these conclusions are not justified by experience nor supported by facts. The difficulties common to such observations are many and various, but they are not nearly so formidable as Prof. Newton would have us believe. Theory will often exaggerate obstacles of this kind, and rarely apprehends how thoroughly they may be overcome by observers who gain aptitude by long practice, who make accuracy their great aim, and exercise discrimination as far as in them lies. If any man will stand in the open and watch for meteors during the whole of some hundreds of clear moonless nights he may discover for himself, and by the best of all methods, viz. practical experience, the degree of accuracy to be attained, the character of meteoric radiation, the amount of reliance to be placed on determinations of positions, and the facility with which individual meteors may be assigned their centres of divergence, &c., &c. At the outset the observer will certainly be confused by the striking diversity in the directions, appearances, and motions of the meteor flights; and, unless some very special showers are in progress, may be led to conclude that the meteors are being scattered broadcast over the heavens without any regard whatever to emanation from definite points. But with practice and a due consideration of the many conditions which may aid him to remove the complexity, he is enabled, after a time, to reduce his observations to satisfactory order and, by very cautiously feeling his way, finally acquires proficiency and confidence in his work. By comparing his annual results he may test the degree of accuracy amongst his radiants. By at once giving each meteor its radiant, he can ascertain his probable error by the evidence furnished from many observations secured at later hours, which will either confirm or negative his earlier impressions. Some of his meteors may also be observed at other stations, which will furnish another excellent check. The intersection of the paths will exhibit the character of the radiation combined with the observational errors; the latter of which need, however, be little regarded, because they are nearly eliminated in the case of practised eyes. And here I would mention that the *direction* of a meteor is quite insufficient, in itself, to enable its radiant to be fixed, for every shooting-star has features depending upon conditions which an observer must duly weigh. The astronomical position of the radiant, the sensible position of the radiant, and the place of the radiant relatively to the observed flight of the meteor, have each to be carefully considered as affording criteria in attributing the real centre which, in combination with an accurate record of the direction of the path, very seldom err. The radiant may thus nearly always be alotted within very small limits of error. The real difficulty consists in the great number of meteor-streams and in their extreme tenuity, which necessitates observations during the whole night long, if they are to be discovered.

Though glancing may affect the November Andromedes to a considerable degree, it does not equally diffuse radiation in the minor showers; and Prof. Newton may rest assured that the Perseid radiant instead of being a wide one, as he says, is a contracted one, which may be traced with great precision and definiteness as it rapidly advances eastwards, during July and August, through the constellations Cassiopeia, Perseus, and Camelopardalus. Its positions from night to night can be followed with certainty and facility, even near the limits of its visibility, when it yields less than one meteor per hour in the extent of sphere commanded by one observer.

Single meteors, instead of being liable to errors of 2° or 3° in the observation of their directions, are rarely liable to errors of more than $\frac{1}{4}$° or $\frac{1}{2}$°. Prof. Newton's statement "that any point above the horizon in a meteor's path may have been its radiant" has astonished me because I have never yet seen a meteor, having a phosphorescent streak, from a radiant anywhere in the whole region of the firmament about the earth's anti-apex, nor one moving slowly and with a train from the region of the apex. Long-pathed meteors do not come from radiants at great altitudes nor short meteors from radiants near the horizon, unless in exceptional cases. Finally, Prof. Newton's statement that "any radiant determined from a small number of meteors is unreliable," is not sound. Four or five meteors accurately observed and displaying an appearance of affinity will often indicate a radiant (particularly if that radiant be rather low in the sky and not far distant from the intersecting tracks) with the utmost precision and safety; though I would not suggest that such slenderly observed positions be always accepted unless they are fixed on approved lines by an observer intimately acquainted with the work.

Radiant-points generally are sharply defined, though one or two meteors in ten will show a little deviation, possibly due to glancing. The radiant of Biela's meteors struck me as a wonderful and very unusual feature when I came out to observe it on the early evening of Nov. 27, 1885. I could not help thinking at the time that it would be much easier to get a satisfactory radiant for a feeble shower supplying about one meteor in five hours than the widely dispersed radiant of this meteor storm yielding its thousands of meteors in an hour! The latter radiant is obviously a special one, and it cannot be safely adopted as typical of others.

Yours faithfully,

Bristol, 1887, Sept. 6. W. F. Denning.

Lalande 26481.

Gentlemen,—

I compared this star micrometrically with Winnecke's Comet on September 10th, 1886. On reducing its position to 1886·0 from the Catalogues of Lalande and Lamont I found a considerable discordance between the results, and made a remark to that effect in my communication in R.A.S. 'Monthly Notices,' vol. xlvii. p. 298. As there is no well-determined star near it for comparison with the filar micrometer of the 8-inch equatoreal, I have recently sought the assistance of Mr. Lenehan, the Acting Government Astronomer at Sydney, who has kindly observed the star with the 6-inch transit-circle. He has communicated to me the resulting apparent places for July 27, 28, 29, and 30 last. On reducing the places given by Lalande, Lamont, and Mr. Lenehan to the beginning of 1886, by means of Peters' elements, I get the following results:—

	Mean R.A. 1886·0. h m s	Mean N.P.D. 1886·0. ° ′ ″
Lalande, 1800	14 25 1·06	105 6 33·4
Lamont, 1850	14 25 2·17	105 6 56·6
Lenehan, 1887....	14 25 2·67	105 7 14·2

It is therefore evident that the star has a considerable proper motion in both coordinates.

Erratum in my communication published in the 'Observatory' of July, 1887:—*For* Kuntz *read* Kreutz.

Windsor, N. S. Wales,
1887, August 15.

Yours faithfully,
John Tebbutt.

NOTES.

New Variable [*].—Prof. Boss finds that the star D.M. + 3°, No. 766, is variable. Its magnitude appears as $9^{m}\cdot 2$ in the 'Durchmusterung,' and likewise in the Bonn Observations; but Prof. Boss was unable to find it with the Albany meridian instrument in 1880 and 1881. He has, however, since picked it up with the 13-inch equatorial as an $11^{m}\cdot 5$ star. It would therefore appear to be either one of the so-called "temporary" stars or a variable of long period.

The Spectra of Hydrogen and Water Vapour [†].—A somewhat striking theory with regard to the relationship of the wave-lengths of the lines in the spectra of compound bodies has recently been put forward by Prof. Grünwald of Prague. His fundamental principle appears to be that the wave-lengths of the lines due to a certain element in a given compound are to the wave-lengths of the lines due to that same element when the first compound is combined with some further body, as the volume the element occupies in the first case is to the volume it occupies in the second. The wave-lengths of the lines of the second spectrum of hydrogen, for example, when divided by 2 give those of the lines of water vapour, the second spectrum of hydrogen Prof. Grünwald considering as belonging to a molecule, H′, of a more complicated structure. The lines of the elementary spectrum of hydrogen he divides into two groups, *a* and *b*, the wave-lengths of which, when multiplied by $\frac{19}{30}$ and $\frac{4}{5}$ respectively, give those of the lines of water vapour. The accord between the wave-lengths thus computed and those of lines actually observed in the solar spectrum is very close.

$$\left.\begin{array}{ll}\text{Since} & [a]+[b]=1 \\ \text{and} & \frac{19}{30}[a]+\frac{4}{5}[b]=\frac{2}{3}\end{array}\right\}$$

$$\text{therefore} \quad [a]=\tfrac{4}{5} \text{ and } [b]=\tfrac{1}{5},$$

whence it is inferred that hydrogen is composed of four volumes of the element *a* with one of the element *b*. Prof. Grünwald seeks to identify these with "coronium" (the element giving the coronal line, 1474 K) and "helium" (the element giving D_3). The latter line falls into the series of lines inferred for *b*; but for 1474 K to belong to element *a*, the elementary spectrum of hydrogen must possess a line as yet unrecognized as belonging to it, of wave-length 3544.

In a similar manner a formula is worked out for oxygen; but this is of a very complicated character, too complicated, one would say, to have much verisimilitude. And it will be seen that the two supposed constituents of hydrogen, "coronium" and "helium," must, on the theory brought forward, exist, together with hydrogen itself, throughout the solar atmosphere; the hydrogen being therefore at the same time both dissociated and intimately combined, which seems hardly probable.

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[*] Gould's Astronomical Journal, No. 160.

[†] Astron. Nach. No. 2797.

Nice Observatory.—The second volume of the Annals of the Observatory founded by the munificence of M. Bischoffsheim has just appeared. It is mainly devoted to the determination of the coordinates of the Observatory—the longitude east from Paris being found to be $0^h\ 19^m\ 51^s{\cdot}225$, whilst the provisional latitude is taken as $43^\circ\ 43'\ 16''{\cdot}9$—and to the micrometric measures of double stars, which form a very fine series. A fourth section contains observations of comets and planets, and the fifth and sixth are mostly occupied with reprints of notes on solar spectroscopy and the "red glows" and "coronæ" of 1883 and 1884, which MM. Thollon and Perrotin have presented to the Académie des Sciences from time to time. The volume, which is beautifully printed, is illustrated by seven fine plates, one being a map of the environs of the Observatory, and another M. Thollon's study of the B group. The present volume, though second in title, is yet the first to appear. The first volume, which will be published shortly, will contain a description of the Observatory and the instruments. The third is also in preparation and will contain the splendid study of the solar spectrum which occupied the late M. Thollon so many years.

The Oxford Uranometria.—The second paper of Vol. xviii. of the Annals of Harvard College Observatory is a discussion of the Oxford Uranometria. The principal part of the paper is devoted to a detailed comparison of the Oxford magnitudes with those of the "Harvard Photometry," and of Wolff's second catalogue. The comparisons seem to show the existence of small systematic errors, the cause of which is not yet ascertained, though the general accord of the three catalogues is satisfactory. The mean differences, H.P. – O.U., show a regular progression with the magnitudes. Thus for stars brighter than the third magnitude it is +0·034, and for the succeeding magnitudes +0·020, –0·079, –0·078, and for stars between the sixth and seventh magnitudes +0·031, the mean difference for all magnitudes being –0·049. This is the more curious as the "Harvard Photometry" assumes the Pole Star, which is the standard of reference in both catalogues, as 2·15, whilst the "Uranometria" takes it as 2·05, so that the H. P. magnitudes, instead of being smaller, should be 0·1 larger than those of the O. U.; Prof. Pickering suggests, as a possible explanation, that if the stars fainter than the sixth magnitude be regarded as aberrant, the other results would point to the use of a slightly different value of the wedge constant.

The Wedge Photometer.—Prof. Pickering, in conjunction with Profs. Langley and Young, presented a paper last November to the American Academy on the Wedge Photometer used by Prof. Pritchard in his photometric work. Prof. Young employed the wedge with the great Princeton refractor on some faint stars near γ Pegasi, and though the test thus applied to it was scarcely parallel to the work on which it was employed at Oxford, the results were very fairly satisfactory. The greater part of the paper is occupied by an account of the detailed testing, by means of his bolometer, to which Prof. Langley subjected the wedge. Whilst showing that, for the purposes and within the limits to which Prof. Pritchard had confined it, the practical value of the wedge was unaffected, this examination brought out some curious and unexpected facts, for the coefficient of transmission increased beyond the red in a very remarkable manner. There was indeed a selective absorption of light throughout the wedge, even in the visible rays, but it was only feeble in the brightest part of the spectrum, though, on the whole, the transmissibility always increased from the violet to the red. Prof. Pickering confirmed this result by independent photometric and photographic experiments. His general conclusion is that valuable results may be attained by the wedge in skilful hands, but that it is liable to sources of error which must be carefully studied before it is applied to stars of pronouncedly different colours, or for detecting small systematic errors in star catalogues.

THE SUPPOSED SATELLITE OF VENUS.—This long-standing astronomical enigma seems at last to have received a solution, at once simple and sufficient, at the hands of M. Paul Stroobant, who has recently presented a paper on the subject to the Brussels Royal Academy of Sciences. M. Stroobant had been studying the question after it had been revived again by M. Houzeau's ingenious theory (see 'Observatory,' Vol. vii. p. 222), published in 1884, and in the course of his inquiry he tried to find out what was the star spoken of in the observation of the Copenhagen astronomers made on Aug. 4, 1761, and was led to the unexpected conclusion that the "satellite" itself was none other than a fixed star. Following out the line of research thus suggested, he found that in the great majority of cases there was at least a probability that a star had been observed, and in several instances there was no reasonable doubt at all that this was what had happened. Thus Horrebow evidently had observed θ Libræ on Jan. 3, 1878, and the motion he ascribed to the "satellite" was really due to Venus herself. So Rœdkiœr seems on different occasions to have observed χ_1 Orionis, ν Geminorum, and *m* Tauri. These are all fairly bright stars, being of the fifth magnitude or brighter, and might be easily seen even when close to the planet; but there was no star of similar brilliancy in the neighbourhood of Venus at the times Short, Montaigne, La Grange, and Montbarron made their respective observations. In Montaigne's case three stars of $7^{m}\cdot1$, $8^{m}\cdot4$, and $7^{m}\cdot8$ respectively, are very near the successive places of the "satellite," so near that but for their faintness, especially as Venus was then at her brightest, and the fact that Montaigne describes the "satellite" as crescent-shaped and 10″ in diameter, there could be no hesitation in concluding that they were the actual objects seen. M. Stroobant has found, however, that, with a telescope of six inches aperture, it was possible to see a star even of the ninth magnitude quite near to Venus, so that the objection from the

faintness of the stars is much weakened
of the disk may have been due to bad
observations are in this way at least pla
been really of fixed stars, and several
observations are rejected—those of Fo
were manifestly due to the bad quality o
during the transit of June 6, 1761, evide
and the only series left unexplained is th
March 1764. It is possible that in on
discovered that one of the larger astero
have been observed; but in the majori
little doubt but that the object seen was

M. Stroobant has completed his pap
He supplies in one table the details of a
"satellite" available, in a series of other t
of Venus at the times when the observatio
a series of diagrams illustrating the posi
stars at the times named. He has like
of the different theories which have bee
in order to account for the observation
more important still, since some were
reprinted the original observations the
Stroobant's paper is the most important
been made to the literature of an intere
ject; and there can be no reasonable d
considerable extent at least, given a s
what has been a puzzle to astronomers f

NEW OBSERVATORY.—M. Flammarion
erection of a new observatory. It is s
road from Paris to Fontainebleau, and is
chateau admirably placed, which, toget
encircles it, was presented to M. Flam
his many astronomical admirers. The h
convent in 1730, possessed walls so thic
admirable base for the dome and equat
9½ inches in aperture and 12½ feet in
glass being by Bardou and the clockwor
governor being attached. Two smaller
adjoining terrace. M. Flammarion is al
of a fine astronomical library, and is for

NEW VARIABLE STAR OF THE ALGOL-TY
has discovered that the star 155 Canis
a variable of the Algol type. On Mar
that the star appeared unusually faint as
bouring stars Nos. 144, 156, 165, and 1
only two evenings before it had seemed
The star was observed again on Marc

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* Gould's Astronomical Jour

days, but was of about normal brightness on each occasion until April 11, when it was again observed near minimum. Two other observations were secured when the star was near minimum; one on April 19, when the recovery was well watched, and the other on April 20 during an apparent decrease. The star was, however, very low at this observation. The period will, therefore, be some aliquot part of eight days, and if the observation of April 20 be accepted, it will be about $1^d\ 3^h$. It is uncertain as yet whether the star has been observed at the actual minimum; the observed variation has, however, amounted to about half a magnitude.

The place of the star, which as the first certainly variable star in the constellation will probably be called R. Canis Majoris, is for 1875.0, R.A. $7^h\ 13^m\ 49^s$, Decl. 16° 9′·7 S.

PUBLICATIONS OF THE MORRISON OBSERVATORY.—We have received No. 1 of the Publications of the Morrison Observatory, Glasgow, Missouri, U.S.A. Prof. Pritchett, the Director (whose name is well known to our readers), gives in this volume a description of the Observatory and instruments (the principal ones being an equatoreal refractor of 12¼ inches aperture, and a meridian circle with 6-inch object-glass), details of the determination of the geographic co-ordinates of the meridian pier, and some miscellaneous observations and notes. The latter include measures of double stars, observations of the Transit of Mercury May 5–6, 1878, occultations, measures of the diameter of Mars, observations of Jupiter (special attention having been paid to the Red Spot), of Saturn, of Uranus, of Comets, and of the new star in the Nebula in Andromeda. The results of some of these observations have already been published in the 'Astronomische Nachrichten,' 'Monthly Notices,' or 'Observatory;' and astronomers will doubtless be glad to have the opportunity of examining them more in detail.

THE LEANDER MCCORMICK OBSERVATORY.—The following are the chief points of interest mentioned in Prof. Ormond Stone's Report for the year ending June 1, 1887, which has recently been published. During the year the brighter portion of the Orion Nebula has been repeatedly examined with the 26-inch equatoreal, for the purpose of determining the relative brightness of the various condensations of which it is composed, with the object of detecting, if possible, any changes in brightness in the nebula. 351 observations of miscellaneous nebulæ have been made, 270 of which are supposed not to have been hitherto detected. A working list has also been prepared, containing all known nebulæ north of 30° south declination which are as bright as the 14th magnitude and condensed at the centre; it is proposed to observe the positions of these as accurately as possible as a step towards the determination of their proper motions. During the year, 176 such observations have been made; 439 micrometrical measurements of position-angles and distances of southern double stars have also been secured.

THE NOMENCLATURE OF DOUBLE STARS*.—We heartily endorse Prof. Asaph Hall's protest against the prevalent practice of designating double stars by means of symbols, or the initial letters of astronomers, which require considerable ingenuity and labour to understand. Of course the symbols Σ and OΣ, used to designate the Struves, are well known, and may be adhered to without risk of confusion; but we agree with Prof. Hall in thinking that it would be better to omit the introduction of new symbols until the astronomer so designated has found a pretty large number of new double stars.

THE TRANSIT OF VENUS, 1882.—The Report of the Committee appointed by the British Government to superintend the arrangements to be made for the sending of expeditions at the Government Expense, and securing co-operation with the Government Expeditions for the observation of the Transit of Venus, December 6, 1882, has been published. The following stations were occupied by expeditions sent directly from England:—Jamaica, Barbadoes, Bermuda, Montagu Road (Cape of Good Hope), Madagascar, New Zealand, Brisbane. An additional equatoreal was sent to the Cape Observatory, and two equatoreals for the equipment of a station at Aberdeen Road, Cape of Good Hope, from which observers were supplied from the Staff of the Cape Observatory. The observations at all of these stations were successful, with the exception of Brisbane, where cloud and rain interfered; and the observations at these stations were supplemented by observations at Natal, Mauritius, Australia, New Zealand, and Canada, which have been directly forwarded to the Committee, and discussed in the Report. Mr. Stone, the Directing Astronomer, gives the following as the results of his discussion of the observations of the various contacts:—

External Contact at Ingress	....$\pi = 8''\cdot760 \pm 0''\cdot122$.
„ „ Egress	....$\pi = 8''\cdot953 \pm 0''\cdot048$.
Internal Contact at Ingress	....$\pi = 8''\cdot823 \pm 0''\cdot023$.
„ „ Egress	....$\pi = 8''\cdot855 \pm 0''\cdot036$.

With regard to the observations of internal contact at egress, if the recorded times of contact which are stated to correspond to "haze or shadow" be combined with observations where only one time is recorded, the result is (I.) $\pi = 8''\cdot827 \pm 0''\cdot050$; if, however, the latter observations be combined with times which are stated to correspond to "limbs of Sun obscured or geometrical contact," we have (II.) $\pi = 8''\cdot882 \pm 0''\cdot043$. Mr. Stone states that the probable errors of these two results are so nearly equal that it has been thought desirable to give a third solution, on the assumption that the mean of the times recorded for the different kind of contacts by some of the observers would on the average best agree with the kind of contact to which the single time records refer; hence

---

* 'Astronomical Journal,' No. 159.

(III.) $\pi = 8''\cdot855 \pm 0''\cdot036$ is, in Mr. Stone's opinion, probably the value which best represents the egress observations here collected.

If we adopt the mean of the results for ingress and egress we obtain from the internal contacts $\pi = 8''\cdot839 \pm 0''\cdot021$ or $\pi = 8''\cdot825 \pm 0''\cdot028$, according as we take the third solution or the first solution for the egress result. These agree so closely that the value $8''\cdot832 \pm 0''\cdot024$ may be accepted as that which represents the internal contacts. This value corresponds to a mean distance of the Earth from the Sun of 92,560,000 ± 250,000 miles. The details of the observations given by the different observers are published in Mr. Stone's Report.

TOTAL SOLAR ECLIPSE OF AUGUST 19.—We learn from 'Ciel et Terre' for Sept. 1, that M. Niesten, of the Brussels Observatory, attained a fair measure of success in his observation of the late eclipse. Owing to a delay in the arrival of his instruments he was not able to get as far as Perm, where he had intended to take up his position, and he therefore joined M. Bjelopolsky, of the Moscow Observatory, at Turjevetz, on the Volga. Although the morning of the eclipse was cloudy, it fortunately happened that the sky cleared a little round the Sun at the time of totality, and he was able to see not merely the chromosphere and prominences, but also some of the coronal rays, of which one, nearly in the direction of the solar equator, was strongly marked, and is represented in a drawing M. Niesten made as extending about a degree from the Sun. M. Niesten's assistant also secured eight photographs, of which six were good. The exposures varied from eight to thirty seconds; the chromosphere and prominences were shown on all, and two of them gave traces of the brighter part of the corona and also of Regulus, which was near the Sun. A photographer from Moscow, M. Karinne by name, who was also at Turjevetz, secured several photographs.

The Siberian parties also seem to have been quite successful. M. Chamontoff was able to photograph the corona very successfully at Krasnojarsk, in the Government of Yeniseisk; and at Tomsk the corona was very well observed, the weather being very fine and the sky clear; so that, though the results obtained from the eclipse are far more meagre than was hoped, yet it has not been altogether a failure.

θ^1 AND θ^2 TAURI.—Mr. Lynn writes to us with respect to these stars to point out that the proper motion of θ^2, as set down in the Greenwich observations, is probably erroneous, and that the apparent distance of the stars is most likely slowly diminishing, not increasing, as the relative proper motion $+0^{s}\cdot007$ in R.A. would imply. The proper motion of θ^2 in R.A. as given in the Greenwich Catalogues, viz. $+0\cdot007$, that of θ^1 being *nil*, depends upon a comparison of Bradley's places with those of the Greenwich

12-year Catalogue. The latter, however, contains only two observations of θ^1, and only one of θ^2, whilst Bradley's observations were made over one wire only, and were taken merely to the nearest half-second, so that all that can be concluded from them is that the difference in R.A. was then between 5^{s} and 6^{s}. In Pond's Catalogue of 1112 stars the distance in R.A. for 1830 is $5^{\mathrm{s}}{\cdot}73$; in the Greenwich nine-year Catalogue it is for 1872, $5^{\mathrm{s}}{\cdot}52$; a slight decrease. In N.P.D. Pond's Catalogue gives $\theta^2-\theta^1=5'\ 27''{\cdot}9$, whilst the nine-year catalogue makes it $5'\ 28''{\cdot}35$; an increase of $0''{\cdot}45$ in 42 years.

NEW MINOR PLANET.—A new minor planet, No. 269, was discovered by Herr Palisa at Vienna on Sept. 21. Minor planet No. 267 has received the name of Tirza.

THE Editors would be glad to receive observations of the satellites of Saturn, and of the maxima and minima of variable stars, to assist them in the preparation of the "Companion" for 1888.

Elements and Ephemeris for Olbers' Comet *.

By A. LEBEUF.

THE comet discovered by Mr. W. H. Brooks on Aug. 24 has proved to be, as was at first suspected, the comet discovered by Olbers on March 6, 1815. The following provisional parabolic elements and ephemeris are deduced from observations made on Aug. 27 at the Observatory of the Collegio Romano, on Aug. 30 at Besançon and Nice, and on Sept. 2 at Nice.

T=1887 Oct. 10·8815, Paris M.T.

π	$153^\circ\ 25'\ 33''$	Mean Eq. 1887·0.
☊	85 12 29	
i	45 7 21	
log q	0·07233	

Error of middle place (O−C).

$\Delta\lambda \cos\beta = +6''{\cdot}5.$ $\Delta\beta = +7''{\cdot}3.$

Ephemeris for Paris Midnight.

1887.		R.A. h	m	s	Decl. °	′	Log r.	Log Δ.	Brightness.
Oct. 1	..	11	30	59	+27	41·3	0·0757	0·2731	1·71
3	..	11	41	2	27	12·4			
5	..	11	51	0	26	41·1	0·0735	0·2714	1·74
7	..	12	0	54	26	7·5			
9	..	12	10	42	25	31·9	0·0724	0·2709	1·75
11	..	12	20	23	24	54·2			
13	..	12	29	57	+24	14·8	0·0726	0·2715	1·75

The brightness on Aug. 27 is taken as unity.

Mr. Backhouse writes to us to state that Olbers' comet has a tail: "a faint broad one was traceable on Sept. 26 at $16^{\mathrm{h}}\ 37^{\mathrm{m}}$ to a length of $\frac{1}{4}^\circ$, although there was moderately bright twilight, and I believe there were also thin clouds in front."

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* Astron. Nachr. No. 2805.

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,

A. M. W. DOWNING, M.A., F.R.A.S.,

AND T. LEWIS, F.R.A.S.

CONTENTS.

PAGE

Meeting of the Liverpool Astronomical Society 369

Articles:—

The Total Eclipse in Japan. By David P. Todd, F.R.A.S. 371
Airy's Numerical Lunar Theory. By M. R. Radau 377
Meteor Notes. By W. F. Denning, F.R.A.S. 384
Selenographical Notes. By T. G. Elger, F.R.A.S. 386

Correspondence:—

The Rotation of Algol. By J. M. Barr 388
Pritchard's Photometer. By Edmund J. Spitta, F.R.A.S. 389
OΣ 256. By John Tebbutt, F.R.A.S. 391
The Periods of the Planets. By Prof. Ch. V. Zenger 391

Notes:—

New Variable Stars.—The late Prof. Kirchhoff.—The Pulkowa Catalogue of 3542 Stars for 1855.—Publications of the Washburn Observatory.—Southern Double Stars.—The Dearborn Observatory.—The late Joseph Baxendell, F.R.S.—New Minor Planets 395-400

Elements and Ephemeris for Olbers' Comet, 1887. By O. Tetens 400

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CONTENTS OF No. 128.

PAGE
Twelfth Meeting of the Astronomische Gesellschaft, 1887, August 29 to 31 337

Articles:—

Airy's Numerical Lunar Theory. By M. R. Radau 339
Account of further Observations of the Lunar Crater Plato in the years 1882–84. By A. Stanley Williams, F.R.A.S 345
Meteor Notes. By W. F. Denning, F.R.A.S. 351
Selenographical Notes. By T. G. Elger, F.R.A.S 354

Correspondence:—

The Comet discovered by Montaigne and Olbers in 1780. By W. T. Lynn, B.A., F.R.A.S. 355
The Variable Star Algol. By W. H. S. Monck, M.A., F.R.A.S 357
The Determination of Meteor-paths and Radiants. By W. F. Denning, F.R.A.S. 358
Lalande 26481. By John Tebbutt, F.R.A.S. 360

Notes:—

New Variable.—The Spectra of Hydrogen and Water Vapour.—Nice Observatory.—The Oxford Uranometria.—The Wedge Photometer.—The supposed Satellite of Venus.—New Observatory.—New Variable Star of the Algol-type.—Publications of the Morrison Observatory.—The Leander McCormick Observatory.—The Nomenclature of Double Stars.—The Transit of Venus, 1882.—Total Solar Eclipse of August 19.—θ^1 and θ^2 Tauri.—New Minor Planet.—Editorial Note 361–368

Elements and Ephemeris for Olbers' Comet. By A. Lebeuf 368

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 129. NOVEMBER. 1887.

Meeting of the Liverpool Astronomical Society.

THE seventh session of the Liverpool Astronomical Society was opened on Monday evening, October 10th, at the Royal Institution. Eighteen ordinary members were elected, and sixty-one candidates were proposed for election; and Director O. von Struve and Professor Schiaparelli were elected Associates of the Society. In his address the President, Mr. W. F. Denning, F.R.A.S., referred to the last volume of the Journal as evidencing the varied and attractive character of the work in which the members had been engaged. Micrometrical measures of fifty double stars had been completed by Mr. Tarrant, and Mr. Elger had continued his selenographical studies, and had contributed a valuable series of illustrated papers during the session. Mr. Elger had also observed the remarkable dark patches in the "crape" ring of Saturn, which had been independently detected by Dr. Terby at Louvain, in Belgium. A wide spread feeling of regret had been caused by the announcement that the eclipse expedition of the Society to Russia, undertaken by Miss Brown, had been a failure owing to the prevalence of cloudy weather on the 19th of August last. From the observations of Jupiter reported by the planetary section, it appeared that the red spot continued visible, and showed a further increase in its rotation period. The meteoric section had also made considerable progress. With reference to the future work and prospects of the Society, Mr. Denning said:—"A mass of work is contemplated during the ensuing session. Mr. Tarrant has already observed and measured an additional two hundred double stars, and the results are being prepared for publication. In connection with the meteoric section, more than 1200 shooting-stars have been seen at Bristol during the months June to September 1887, and Mr. Booth, of Leeds, has recorded about 300. The work will be closely pursued during the autumn and winter months. Mr. Elger will resume his observations of Saturn when the planet becomes more favourably situated. The phenomena observed in the 'crape' ring will be carefully looked for by nearly everyone interested in planetary detail. The forms described, if reproduced during the coming opposition, must be sedulously watched during any changes of shape, position, or distinctness, as they are likely to enlarge our knowledge of the Saturnian system. In other departments equal activity is evident, and the opening session gives promise of many important issues. Our American members, who have so disinterestedly set aside national prejudices to support our efforts, and enter into a bond of fellowship with English observers, are to be congratulated on a policy which has afforded the home members no small amount of satisfaction. It is to be hoped that the excellent example set by the Pernambuco Branch may ultimately lead to a great extension in the Society's connections and sphere of usefulness. In an association like the Liverpool Astronomical Society, where so much has to be arranged by correspondence, many difficulties and obstacles confront the executive from time to time. The duties of our Secretary, Mr. Davies, are of an extremely laborious nature, and the Society has necessarily to rely much upon his tact and discernment. It therefore becomes the duty of the members to support his efforts as far as possible, for the present efficient state and high position of the Society are almost entirely due to his spirited policy and untiring zeal. Misapprehensions must occasionally a ise and dissatisfaction will be sometimes felt even under the most perfect *régime*; but considering the circumstances under which our Society is carried on, and the many different influences and interests it has to accommodate, there is real cause for satisfaction . . . . That the Liverpool Astronomical Society fills a great want is amply proved, and it is sure to exercise a most beneficial effect in stimulating and training amateurs, and thus leading them on to effect important work in future years. With such noble ends in view no true astronomer will throw obstacles in the way, or fail to promote the Society's interest in its desire to 'foster a liking for astronomy amongst the possessors of small telescopes.' We must remember that small beginnings have often led to great results. Schmidt commenced his lunar studies with a small telescope, made by his father, and steadied by a lamp-post while he observed; and few would have thought it possible that the first humble efforts of William Herschel could have paved the way to the astonishing success of his later efforts."

Mr. T. Gwyn Elger, F.R.A.S., read a paper on the lunar walled-plain Fracastorius; the first of a series of papers dealing with these interesting formations to be published during the ensuing session. In the course of his paper he described and illustrated the principal details as they appear at sunrise and sunset, especially such as are then revealed on the partially destroyed north border. In the next article he proposed to discuss the system of light spots and streaks, the "rills," and other features in the interior of this formation.

Papers were also read on "The Spectroscope in relation to

Binary Stars," by W. H. Monck, M.A., F.R.A.S.; on "Saturn," by Mr. Elger; on "Some supposed Variable Stars in the Pleiades," by Herr Thorvald Kohl; and on "The Comet of B.C. 44," by W. T. Lynn, B.A., F.R.A.S.

Preliminary arrangements were entered into for the formation of a Glasgow and Paisley Branch of the Society.

It was announced that the next meeting on November 14th would be held conjointly with the Liverpool Literary and Philosophical Society.

The Total Eclipse in Japan.

Early in the present year, the Trustees of the Bache Fund of the National Academy of Sciences, Washington, made a grant to Professor Newcomb, Superintendent of the Nautical Almanac, for observing the total solar eclipse of the 19th August, 1887. Professor Newcomb decided upon locating the observing-station in Japan, determined the general lines of research to be undertaken, and placed me in charge of the Expedition. After some weeks of preparation in Washington and elsewhere, I left Boston the 9th June for Japan, going by way of Montreal and the Canadian Pacific Railway to Vancouver, the coast terminus, and thence embarking for Yokohama in the steamship 'Abyssinia,' the first west-bound ship of the now regularly established Trans-Pacific line owned by the Canadian Company.

Yokohama was reached the 8th July, and steps were at once taken toward locating the instruments in the most advantageous spot. Meteorological indications were only of the most general character, and far from precise. The stations of the Japanese Meteorological Service being all on the coasts, there was little to enable one to form even a fair guess as to what the chances in the interior might be. I have to thank the officers of this service for much assistance, especially Dr. E. Knipping, the Meteorologist of the Imperial Central Observatory at Tokio. On general grounds, he with others thought that the chances of a clear August afternoon were rather better on the west coast, near Niigata, say, than elsewhere. And thither I should doubtless have gone without enquiry, but that the means of sea-transportation were uncertain, while the journey by pack-horse over the mountains of western central Japan seemed, with the weighty boxes, in every way inexpedient.

As I had abundant time, I determined upon a hurried reconnaissance of eastern central Japan, along the line of the Japanese Railway Company, then extending northward from Tokio through Utsunomiya (65 miles) to Shirakawa (113 miles), and now open as far as Fukushima and Sendai. The President of the Company, Mr. Narabara, I have great pleasure in thanking for his courteous offices on this and subsequent occasions. The region between Utsunomiya and Shirakawa was, in my judgment, very unsuited for an eclipse station, on account of its broken and hilly character, and the proximity of the mountain ranges lying west. I found Utsunomiya itself situate in a broad plain, and apparently very favourable meteorologically, but too far from the line of central eclipse; while Shirakawa was as nearly as desirable in the central line (some ten or twelve miles north of it), and twenty-five or thirty miles from the mountains to the west—far enough, it seemed, to be without the range of their perturbing effect upon the clearness of the sky.

At any rate, a careful balancing of the *pros* and *cons* for all likely stations led to my decision that Shirakawa was the best place for the location of at least the greater part of my instrumental equipment. Professor Pickering, Director of the Harvard College Observatory, who provided the expedition with most of its apparatus for specialized research upon the corona, desired me, if practicable, to place all or a portion of it on the summit of one of the mountain-peaks, of which there are several adjacent to the centre of the shadow-path, notably Nantaisan, 8500 feet high. Dr. W. J. Holland, whom I had invited to accompany the expedition as naturalist, made the ascent of this mountain; but his report of its difficulties, together with the highly probable cloudy condition of the summit at the time of the eclipse, led me to abandon the mountain project. The other peaks were too far away from the central station to permit of occupation, with the time and assistance at my disposal. The entire apparatus, therefore, was brought to Shirakawa, and the work of preparation actively begun four weeks before the day of the eclipse.

Here I was most fortunate in having from Count Oyama, the Minister of State for the Army, permission to establish my station on the ruin of the celebrated old castle occupied by the Abe family until the revolution of 1868. The main instrument was a horizontal photoheliograph of nearly forty feet focal length—the identical apparatus used by Professor Newcomb in 1882 at the Cape of Good Hope, in photographing the transit of Venus. Two weeks' time was quite sufficient for the substantial completion of this instrument, in so far as the parts required for photographing the partial phases of the eclipse were concerned. Of these we had planned to secure 100 pictures; but I had determined also to attempt coronal photography with the same apparatus, hoping to obtain eight or ten negatives of the corona of such size that subsequent enlargement would be undesirable. At the focus of this telescope the Sun's image has a diameter of four and a half inches, and dry plates 17 × 20 inches had been provided for this work; and an extra mirror, finely silvered by Brashear, was taken along for the heliostat, to replace the unsilvered reflector ordinarily employed, shortly before totality. Special modifications of the exposing-shutters and the plate-holders had to be made, and a light-proof tube or camera the whole length of the telescope had to be constructed before the complete drill for the eclipse could begin, and this required a week or ten days more. As was anticipated, too, we found on photographing artificial crescents—very slender ones—that no image of the plumb-line appeared on the plate: there was thus no initial line of reference for the measurement of position-angles. Mr. Hitchcock, whom I had appointed photographer of the Expedition, undertook a variety of experiments to overcome this difficulty, and with entire success. The form of apparatus finally adopted will be detailed in the report of the expedition.

To assist in the operations of the photographic house, we were fortunate in securing the services of Mr. K. Ogawa of Tokio, a Japanese photographer of wide experience, and Dr. Y. May King, of Amoy, also a highly skilled manipulator. For some minutes immediately before the beginning and after the end of totality, the partial phase exposures were to be made every 15 seconds; while the large plates for the corona, with exposures varying from 1 sec. to 15 sec., were to be handled as rapidly as possible. We found that there was a loss of about 5 seconds between the plates—or something like one-sixth the entire duration of totality. With so efficient a photographic corps, and the drill which we all underwent, I had the best of reason for anticipating complete success. As wet plates seemed in many ways preferable to dry ones for the partial phases, Mr. Hitchcock and Mr. Ogawa undertook a thorough series of experiments in preserving sensitized films, at first with glycerine, and subsequently more successfully with sugar. The results of this work made the wet plate, with its fine-grained film, as available for rapid manipulations in the photography of celestial phenomena, as the dry plate has hitherto been found to be. It was shown that the plates might with entire safety be removed from the sensitizing bath from two to four hours before exposure and development, if treated with the sugar preservative, and proper precaution was taken to keep the films from drying. The details of this process will be embodied in the report of the expedition. As an extreme test, we exposed, on the day after the eclipse, a box of plates which had been sensitized and preserved some twenty-six hours previously, and found that they gave sun-pictures photographically perfect.

Shortly before the expedition left America, Mr. Whitney, the Secretary of the Navy, detailed two officers from the Asiatic Squadron, U.S.S. 'Monocacy,' to join me on my arrival in Yokohama. Lieutenant Southerland and Chief Engineer Pemberton accordingly reported for eclipse-duty, and their services were zealously and most effectively rendered. In addition to his work as executive officer, I placed Lieutenant Southerland in charge of the 9-ft. coronagraph sent out by the Pickerings. The objective of this instrument was the 7¼-in. Clark glass of the equatorial of

my own observatory at Amherst; while
instructions for their manipulation, w
furnished by the Pickerings to Professo
his Russian station a $6\frac{5}{8}$-in. Merz glass,
transit instrument of Amherst College
yet been able to learn whether Professor
a clear sky during totality; but, if he w
table that clouds covered the Sun at Shi
attempt to obtain reliable evidence of ra
has thereby come to naught. It will be
eclipse occurs with two stations geographi
special research as were Russia and J
also looked after the mounting of Pr
coronagraph—two five-inch lenses of a
operation of which was entrusted to
while Dr. D. B. McCartee attended to
in. short-focus camera, and Mr. C. R. G
of plate-holders for determining the ac
light. I should have mentioned previ
Mr. Pemberton in rendering the phot
for rapid work than I had found it form
idea that, by means of a system of li
pulleys, led from the heliostat into th
chief astronomer making the exposure
mirror under his immediate and constan
with the customary assistant at the heli
mirror in right ascension and declinatio
rather complex system were practically e
and sufficed to give me perfect comma
dark room. A very simple device m
bright reflected image of the Sun whil
room, and adjust it accurately on the
exposing-slide.

The importance of Newcomb's and
the outer corona in 1878, and attempte
not escaped me, and I had an occulti
attached firmly to the gable of the pho
shadow as cast by the eclipsed Sun woul
in the area enclosed by the upper castl
Mrs. Todd, assisted by Professor Kik
versity, and provided with all the par
sketching in their correct relations the
the corona.

Of two $3\frac{1}{2}$-in. telescopes lent by Adn
of the Imperial Japanese Navy, one w
observation of first and fourth contact
Mercurial planets, while the other was
with instructions to sketch as far as
corona adjacent to the solar poles.

Mr. Nakagawa, Director of the Naval Observatory, with his assistant Mr. Shirai, made a thorough series of meteorological observations throughout the eclipse period, following the system elaborated by Von Bezold, and recommended by the German meteorological conference for the observers in Russia. On the north-west corner of the castle wall I stationed Mr. K. Acino, a student of Astronomy in the University, to make detailed and precise observations of the diffraction bands, and to observe, if possible, the sweep of the lunar shadow across the extensive rice-fields below.

The purely eclipse-results of the work at Shirakawa were disheartening in the extreme. The forenoon gave us a perfect sky, with no indication whatever of approaching cloud; all were confident of entire success. But about an hour before the time of first contact, a slender finger of cloud began to rise from the west, coming at first directly above the summit of Nasutake, a volcano about 25 miles away, and which had sprung into unwonted activity during the past night, belching forth for hours enormous volumes of smoke and steam. The Sun was entirely invisible during the first half-hour of the eclipse, when a brief interval of partly clear sky gave time for adjusting the heliostat and making ten or twelve exposures. The Sun being very faint, only five of these photographs are available for measurement, and these were the only pictures that could be taken with the photoheliograph. The dense clouds, leaving a large clear area most of the time about the zenith, lay over the Sun until the eclipse was past, save only a moment shortly after totality, when there was a partial clearing, but too brief and the Sun too faint to allow of the necessary adjustments of the silvered mirror, which had been put into position in the vain hope of getting the whole or a part of the total phase. As totality drew near, it suddenly occurred to me that a good observation of second contact might be possible by watching for the approach of the Moon's shadow among the clouds; but my attempt to do this failed, the light appearing to me too much diffused to permit of anything better than a rough approximation to the time of contact. I found subsequently, however, in Mrs. Todd's notes on the eclipse, the statement that totality appeared to her to come on, not evenly, but as if by jerks—a phenomenon which may, I think, have been due to the extinction of the Sun's light from one cloud after another as the lunar shadow advanced over the north-western sky.

The weather-maps for the 19th August, which came to our station from Tokio the day after the eclipse, gave us some idea of the odds we had been labouring against; the sheet for 2 P.M. showed clouds at all stations of the Meteorological Service except one, and that far removed from the belt of totality. In general, the whole of the main island was obscured on the eventful afternoon; and a view of the eclipse was permitted only to those so fortunate as to be located in the line of the small apertures, here and there, through the general cloud area. These were numerous enough to enable voluntary observers, scattered all over the central portion of the belt of totality, and for whom I had prepared instructions, to obtain a goodly number of drawings of the corona. These instructions had been translated into Japanese, and printed and distributed through the co-operation of the Department of Education, and the Bureau of Geography of the Department of the Interior. Altogether there are something like a hundred such drawings, but their value is uncertain until they are properly collected. I prepared also instructions for observers of simple duration of totality, hoping to obtain additional data for the position and direction of motion of the Moon's shadow. These were simply distributed under like auspices to a large number of observers just inside the limits of the shadow-path; but no responses of value were received from these stations.

Other expeditions in Japan fared ill also—some of them worse than my own. That sent out by the University in charge of Professor Terao, and located a few miles south of Shirakawa, at Kuroiso, experienced not only heavy clouds but much rain during the eclipse, and no observations could be made. At Sanjo, on the central line and south-east of Niiga'a, Professor Arai, Director of the Meteorological Observatory, was able to make successful exposures for the corona with a small telescope; his negatives had not yet reached Yokohama on my departure, and had not been developed. It was reported clear during the whole of the eclipse at Choshi, a point on the eastern coast near the southern limit of total obscuration; but there were no observers or instruments there for scientific work. It was reported cloudy thoughout the whole eclipse at Niigata; while a party of observers who had ambitiously climbed to the top of Nantaisan, brought down a record of nothing but clouds and fog. On the whole, Japan appears to have been an uncanny spot to lead an eclipse-track across. This condition of things was apparently suspected by Mr. Morioka, the President of the Nippon Yusen Kaisha (Japan Steamship Company), who organized a large excursion party which sailed in the 'Nagoya-maru' for a point in the belt of totality off the east coast of Japan; but they were debarred from a view of all except the first part of the eclipse, and missed seeing totality completely, although possessed of the unique advantages of an observing station variable in position at will.

Aside from the eclipse, however, an expedition to Japan has not been so dismal a failure all told. Dr. Holland has been actively engaged in botanical and entomological research in fruitful fields, and has a good harvest to report. He has also valuable notes upon his ascent of Nantaisan, Asama-yama, and Nasutake. Finally, the expedition to the summit of Fuji-san, which I had the pleasure to carry out under the auspices of the Boyden Fund of the Harvard College Observatory, and on which I had the valued co-operation of Dr. Knipping, resulted among other things in the determination of its rare fitness as a site for astronomical observation—of which more elsewhere. DAVID P. TODD.

180th Meridian, SS [illegible] Victor;
1887, S [illegible]

Airy's Numerical Lunar Theory.

[Continued from p. 345.]

Il s'agit maintenant, et c'est ce que M. Airy se propose dans la Section VII, de chercher les corrections des coefficients g, h, k des trois séries $\frac{r}{a}$, v, l, par lesquelles ces résidus seraient annulés. M. Airy commence par former les variations des trois équations fondamentales (10), (11), (12), qui correspondent aux variations $\delta\frac{r}{a}$, δv, δl des expressions $\frac{r}{a}$, v, l, primitivement adoptées. Pour obtenir, avec la précision demandée, les facteurs qui multiplient les variations $\delta\frac{r}{a}$, . . . ou leurs dérivées $\frac{d}{dt}\delta\frac{r}{a}$, . . . , il suffit ici de considérer un petit nombre d'arguments; mais ces variations elles-mêmes se décomposent en séries où figurent les corrections des coefficients d'une centaine d'arguments. En égalant à zéro l'ensemble des termes qui ont le même sinus ou cosinus en facteur, on obtient une équation de condition pour quelques-unes de ces corrections. Il y a, en tout, 300 équations de condition; chacune des équations (10), (11), (12) en fournit 100. Le procédé de multiplication employé pour les former est exposé en détail dans la Section VIII, et les équations elles-mêmes sont données dans la Section IX.

Comme le nombre des inconnues est égal à celui des équations, leur solution directe serait assez pénible. M. Airy a dû recourir à une méthode d'approximation qui conduit rapidement au but. Les équations de condition dérivées des équations (10) et (11) forment des couples, correspondant au sinus et au cosinus du même argument; en négligeant les termes de moindre importance, il est souvent possible de leur donner la forme

$$a+b\,.\,\delta g+c\,.\,\delta h=0,$$
$$d+e\,.\,\delta g+f\,.\,\delta h=0,$$

de sorte que chaque couple fournit les valeurs de deux inconnues. Mais, dans beaucoup de cas, le dénominateur $(bf-ce)$ devient très petit, les deux équations ne peuvent être considérées comme distinctes, et il vaut mieux les ajouter ensemble, de manière qu'elles n'en forment plus qu'une seule; et, comme on a quelques raisons d'admettre que les corrections δg des coefficients g des cosinus sont de beaucoup les plus importantes, M. Airy fait simplement $\delta g = 25\,.\,\delta h$, pour séparer les inconnues. Enfin les équations de conditions dérivées de l'équation (12) fournissent chacune la valeur approchée d'une inconnue, par un procédé de sélection analogue. La détermination des corrections δg, δh, δk des coefficients g, h, k fait l'objet de la Section X. On y trouve aussi les valeurs corrigées de ces coefficients, et par suite les expressions définitives de la parallaxe, de la longitude et de la latitude de la Lune, dans l'hypothèse de la sphéricité de la Terre et de l'invariabilité des éléments de l'orbite du Soleil.

Voici quelques nombres qui donneront une idée des changements apportés aux coefficients primitifs (ceux de $\frac{a}{r}$ avaient déjà subi quelques altérations légères, comme on l'a dit plus haut; ils se rapprochent maintenant tout-à-fait des coefficients d'Adams et de Hansen).

Numéro.	Argument (cos).	$\frac{a}{r}$.	$\frac{a}{r}$ corrigé.	Parallaxe.
				′ ″
1.	0........	+1,0000004	+1,0000000	+57 . 2,33
2.	l........	+ 545077	+ 544981	+ 3 . 6,51
3.	2D − l....	+ 99813	+ 100238	+ 34,31
4.	2D	+ 82320	+ 82480	+ 28,23
5.	2l	+ 29794	+ 29701	+ 10,17
6.	2D + l....	+ 8950	+ 9021	+ 3,10
..	....	....	....	....

Numéro.	Argument (sin).	v.	v (corrigé).	Longitude. *nl.*
1.	....	....	....	....
				° ′ ″
2.	l........	+1097573	+1097568	+6 . 17 . 19,0
3.	2D − l ..	+ 222336	+ 222353	+1 . 16 . 26,4
4.	2D......	+ 114887	+ 114895	+ 39 . 29,9
5.	2l	+ 37284	+ 37279	+ 12 . 48,9
..	....	....	....	....

Numéro.	Argument (sin).	l.	l (corrigé).	Latitude.
				° ′ ″
301.	f........	+895027	+895027	+5 . 7 . 41,3
302.	$f+l$	+ 48978	+ 48974	+ 16 . 50,2
303.	$f-l$	+ 48469	+ 48506	+ 16 . 40,5
304.	2D − f ..	+ 30234	+ 30237	+ 10 . 23,7
....	....	....	....	....

Remarquons, en passant, que le nouveau coefficient de sin $(f-l)$ est entaché d'erreur. En effet, il doit avoir le signe négatif; or, en ajoutant à son ancienne valeur la correction +37 (p. 136), on trouve 48432, au lieu de +48506. Mais cette correction $\delta k_{303}=+37$ semble elle-même douteuse, car, si je ne me trompe, elle résulte de l'équation (p. 118, n°. 303)

$$+5+0{,}08\,\delta g_2-0{,}09\,\delta g_{12}+1{,}01\,\delta k_{303}=0,$$

qui donne $\delta k_{303}=+3$, en faisant $\delta g_2=-96$ et $\delta g_{12}=+2$, d'après le Tableau de la page 128; on trouverait $\delta k_{303}=+7$, en tenant compte du terme $+0{,}06\,\delta k_{310}$, provisoirement supprimé. Voici d'ailleurs le résultat de la substitution des corrections définitives

δg, δk dans les dix premières équations de condition de la page 118:

Arg.	Résidus.	Corrections.
301	− 2,5	+14,5=0
303	+ 5	+25,8=0
305	−69	+65,1=0
308	+25	−44,8=0
310	+11,8	− 9,3=0

les équations (302), (304), (306), (307), (309), que nous omettons, sont assez bien vérifiées; mais les cinq autres ne le sont pas. On voit que la détermination des corrections δk de la latitude est souvent assez précaire.

M. Airy a encore essayé de se rendre compte de l'influence que les mouvements du périgée et des nœuds exercent peut-être ici, en comparant l'importance moyenne des résidus et des corrections trouvées pour les arguments de la longitude suivant qu'ils renferment $+l$ ou $-l$; et pour ceux de la latitude, suivant qu'ils renferment $+f$ ou $-f$. La comparison n'a été faite que pour un petit nombre d'arguments choisis parmi les premiers; il y a quelque apparence que les corrections sont plus fortes quand l a le signe négatif dans les arguments. Mais cette partie de l'étude critique de la théorie de la Lune reste évidemment réservée. M. Airy a surtout voulu, par ces longues et patientes recherches, mettre en lumière le fait que la convergence des développements purement algébriques finit par devenir insuffisante, à une certaine distance du point de départ. Il aurait plus de confiance dans un procédé mixte, où les opérations porteriaint directement sur les nombres.

Le Travail que l'illustre et vénérable doyen des astronomes vient de mettre au jour est précisément conçu dans cet esprit. La méthode de M. Airy, sa *factorial method*, comme il l'appelle, est pour nous séduire par sa grande limpidité, et par l'apparente sûreté de la marche. Elle n'en exige pas moins une extrême attention et des précautions nombreuses et minutieuses, si l'on veut se mettre à l'abri des inadvertances et des erreurs accidentelles. Dans le cas qui nous occupe, des précautions suffisantes ont-elles été prises? L'auteur ne paraît pas lui-même très rassuré à cet égard. Les inadvertances que l'on rencontre dans la dernière Partie, qui est plus facile à contrôler, justifient d'ailleurs des craintes sérieuses. C'est dans cette Partie (Section XI–XIII) que M. Airy examine les inégalités dues à la non-sphéricité de la Terre, et aussi, en passant, l'effet de quelques perturbations solaires.

On admettait jusqu'ici que l'ellipticité de la Terre n'a pas d'influence sensible sur le rayon vecteur lunaire, mais qu'elle produit dans la longitude une inégalité de 7″ qui dépend du sinus de la longitude du nœud, puis, dans la latitude, une inégalité de 8″ qui dépend du sinus de la longitude et qui est la réaction de la nutation. M. Airy arrive à des résultats tout autres, sur l'ex-

Ces équations sont assez bien vérifiées par les valeurs

$$p' = +0'',015, \qquad p = +0'',385, \qquad q = 7'',1,$$

et, bien que le calcul ne soit que grossièrement approximatif, il est visible qu'on retombe sur les inégalités de Laplace.

En divisant p' par 60 (valeur de r en rayons terrestres), on trouverait, pour la parallaxe, l'inégalité $-0'',0002 \cos(u-f)$. Dans le récent Mémoire de M. Hill sur les inégalités lunaires dues à l'ellipticité de la Terre, que l'auteur calcule par la méthode de Delaunay, ce terme ne se rencontre pas parmi les petites inégalités de $\frac{1}{r}$; on l'obtiendrait cependant en appliquant au terme $e \,.\, \cos l$ de $\frac{1}{r}$ les opérations (37) et (39) de M. Hill. Laplace l'indique, sans en donner la valeur complète.

Les deux Notes qui terminent le Volume de M. Airy sont consacrées aux effets qui résultent d'un changement du plan de l'écliptique et de la variation de l'excentricité de l'orbite terrestre, sujets déjà traités par M. Airy et par M. Adams dans les *Monthly Notices*, en 1880 et 1881.

Nous arrêterons là cette analyse, déjà un peu longue, en exprimant l'espoir que les ingénieuses méthodes proposées par M. Airy feront leur chemin. Il faut, en effet, le répéter : l'idée fondamentale du Travail entrepris par M. Airy est une idée neuve et féconde ; en y relevant quelques inexactitudes matérielles, quelques distractions, nous ne méconnaissons pas la portée de la conception qui s'y trouve réalisée. Et nous ne perdrons pas cette occasion de rendre hommage au mérite supérieur de l'homme dont tous les astronomes admirent les travaux. R. Radau.

Remarques Complémentaires.

Dans une Note *Sur les mouvements du périgée et du nœud de la Lune* (*Comptes Rendus*, 2 janvier 1872), M. Delaunay, tout en constatant que la convergence des séries qui fournissent ces mouvements laisse beaucoup à désirer, a essayé d'en indiquer les valeurs numériques. Après avoir poussé le calcul, pour le mouvement du périgée $\left(\frac{d(h+g)}{dt}\right)$, jusqu'aux termes les plus importants du 9^e ordre, il trouve des nombres qui, divisés par le moyen mouvement n, conduisent aux résultats suivants :

$$\frac{dg}{dt} = 0,0124736, \qquad \frac{dh}{dt} = -0,0040212, \qquad \frac{dl}{dt} = 0,9915475.$$

Ces nombres, qui d'ailleurs ne sont pas définitifs, diffèrent à peine de ceux que j'ai conclus par induction de la loi de convergence des séries ; l'accord est encore plus complet en appliquant dont les mouvements M sont très petits, il calcule les coefficients p, q en attribuant les valeurs de M aux nombres $m=1+\mathrm{M}$; en faisant, par exemple, pour $u-f$, $1+\mathrm{M}=-0{,}004$ au lieu de $\mathrm{M}=-0{,}004$. Le facteur de T′, dans l'expression du coefficient q, devient ainsi 496 ; ensuite, la multiplication est faite, par erreur, avec le facteur 4964, et l'on trouve finalement $q=-17'',94$ (p. 163).

Les inégalités de la latitude sont déterminées (p. 164) par l'équation

$$\frac{d^2z}{dt^2}+z=\mathrm{Z},$$

où z est mis pour δz. Afin d'avoir tout de suite δl, nous exprimerons Z et δz en secondes. Z contient les termes $-0'',065\cos u$ $-0'',0186\sin f$, dans lesquels $u=t$ et $f=1{,}004022\,.\,t$, et M. Airy trouve

$$\delta z=-0'',065\,.\cos u-22'',73\sin f.$$

Au lieu de $-22'',73$, je trouve $+2''30$; quant au premier terme de δz, il ne vérifie pas du tout l'équation proposée.

Il faut, dans cette équation, remplacer u par $u-90^\circ$, puis ajouter le terme $+\frac{3}{4}m^2z$, où m est le moyen mouvement du Soleil. En désignant par $g-1=0{,}004022$ le mouvement des nœuds, on a $g^2=1+\frac{3}{4}m^2$, et l'équation rectifiée

$$\frac{d^2\delta z}{dt^2}+g^2\delta z=-0'',065\sin u$$

donne $\delta z=-8'',06\,.\sin u$. C'est l'inégalité bien connue qui répond à la nutation. Le terme en $\sin f$ produit une très légère altération du mouvement des nœuds.

Il faut, en second lieu, rétablir, dans l'équation relative à R, le terme négligé $-3\sin \mathrm{l}\,.\,\delta\mathrm{l}$, ou, ce qui revient au même, remplacer $-3\delta\rho$ par $-3\delta r$. (La relation $\rho=r\cos\mathrm{l}$ donne, en effet, $\delta\rho=\delta r-\sin\mathrm{l}\,.\,\delta\mathrm{l}$, puisque, à très peu près, $r=1$, $\cos\mathrm{l}=1$.) On aura donc

$$\frac{d^2\delta\rho}{dt^2}-3\delta r-2\frac{d\delta v}{dt}=\mathrm{R}.$$

En posant $\delta r=p'\,.\cos \mathrm{M}t$, $\delta\rho=p\,.\cos\mathrm{M}t$, $\delta v=q\,.\sin\mathrm{M}t$, il vient

$$-\mathrm{M}^2p-3p'-2q\mathrm{M}=\mathrm{R}',$$
$$-2p\mathrm{M}-q\mathrm{M}^2=\mathrm{T}'.$$

Pour l'argument $u-f$, qui représente la longitude du nœud, nous avons $\mathrm{M}=-0{,}004022$, et, en rectifiant les nombres de la colonne (F), qui sont un peu trop grands,

$$\mathrm{R}'=575\,.\,10^{-10}=+0'',0118,\qquad \mathrm{T}'=145\,.\,10^{-10}=+0'',0030\,;$$

puis

$$-\sin\mathrm{l}\,.\,\delta\mathrm{l}=0{,}09\,.\,8'',2\,.\,\sin f\sin u=0'',370\,.\cos(u-f)-\ldots\,;$$

par conséquent,

$$p=p'+0'',370.$$

Meteor Notes.

In September, between the 6th and 26th, I observed 285 meteors during 35¾ hours of observation, and the positions of 17 radiants were determined. Of these the following were the best defined:—

No.	Date, 1887.	Radiant.		Notes and Comparisons.
		°	°	
1...	Sept. 7–24	5	+10	Slowish. Seen also in Sept. 1884 and 1885.
2...	Sept. 13–24	7	+44	Slowish. Near η Cassiopeiæ.
3...	Sept. 12–22	28	+72	Slow; short. D., 25° +71°, Sept. 1885–86.
4...	Sept. 17–19	41	+38	Swift. D., 40° +40°, Sept. 20, 1876.
5...	Sept. 7–24	64	+22	Swift; streaks. D., 63° +23°, Sept. 21–27, 1879–86.
6...	Sept. 17–22	335	+58	Slow. Seen also in June–July–Aug.
7...	Sept. 7–24	358	+60	Slowish. Heis, 2° +56°, Sept.–Oct.

No. 1, 5° S.E. of γ Pegasi, supplied 15 meteors, and I have recognized it in several former years. No. 3, near *f* Custos Messium (Lalande), I have also previously observed. No. 4, near Algol, was seen here on nearly the same date in 1876; and No. 5 represents a well-defined shower of Taurids. No. 6, near δ Cephei, from which I saw 12 meteors, is singular as being in the same position as radiants seen during the three preceding months, viz.—June 10–28, 335° +57° (10 meteors), July 14–23, 334° +58° (6 meteors), Aug. 6–25, 334° +58° (10 meteors).

The following bright meteors were noted here in September:—

				Path				
Date.			Mag.	From		To		
	h	m		°	°	°	°	
Sept. 17...	10	37	♃	51	+18	66	+24¾	Slow. Train.
17...	13	26	♃	45½	+34	19	+52	Swift; bright streak.
18...	12	14	♃	337	+83	238	+63	Swift; bright streak.
22...	9	19	♀	43	+19½	50	+19¼	Rather swift; bright flash at end.
24...	11	56	♃	235	+80	47	+10	Very, very slow. Train. Duration 13½ sec.; very long path.
24...	11	57	♃	107	+50	125	+49	Swift; streak and flash.

The meteor of Sept. 22^d 9^h 19^m was also seen by Mr. J. L. Stothert at Bath, who describes it as travelling rapidly from the direction of β Andromedæ to 1° or 2° above Pleiades, where it burst into a small shower of sparks. The meteor traversed about four tenths of a line joining β Andromedæ and the Pleiades.

If we adopt the path observed at Bath as from 38° +29½° to 54° +24°, and compare with Bristol, we shall find the radiant of this fine meteor was on the horizon in S. 62° W., or at 249° −17°. The real flight of the meteor through the atmosphere was therefore parallel to the horizon, and the height is found to have been only 14½ miles. Mr. Stothert first saw it when passing over a point between Swindon and Marlborough. At Bristol I did not catch the first appearance of the meteor, being engaged in watching the

N. sky at the time, but turned directly on seeing the flash. It must have been over Wantage at the instant I first observed it. At the end point it was above a place 4 miles E.N.E. of Abingdon and 7 miles S. of Oxford. Its length of path was about 27 miles. No estimates of its duration were attempted, so that its velocity cannot be deduced. If allowance is made for zenithal attraction, the real radiant would be near Antares and close to the June fireball-radiant in Scorpio ('Observatory,' Vol. vii. pp. 136–138). The centre at $249^\circ - 17^\circ$, derived from a projection of the two paths, is only about 20° from the Earth's anti-apex on Sept. 22; the meteor would therefore be travelling very slowly, and the apparently swift motion observed may perhaps be explained by its proximity. A slight error in direction, either in the Bristol or Bath observation, would alter the adopted radiant considerably and increase the height of the meteor at its first appearance, but the end-point at 14½ miles above a place near Abingdon is most satisfactorily indicated by the two observations. Accounts from Oxford, Reading, or London would be very valuable to test the accuracy of the path here assigned. If the meteor's flight was really horizontal from a setting radiant, then it is at least curious how it could have penetrated through a very long range of the atmosphere until within 14½ miles of the Earth's surface and moving nearly parallel with it, before becoming visibly incandescent. Slow orbital speed, combined, possibly, with materials peculiarly fitted to resist combustion, may have enabled this meteor to reach the lower and denser air strata before its disruption was effected. The low path of this body is interesting compared with that of the Perseid seen at Bristol and Leeds on Aug. 14 last, which certainly became visible at a height of more than 110 miles ('Observatory,' Oct. 1887, pp. 352–353). But the velocity of this Perseid would probably be about four times that of the meteor from Scorpio, the relative figures being 39 and 10½ miles per second. The squares of the velocities being proportional to the temperatures produced, it is easy to see that in the Perseids and other apical meteors the heat generated is immensely greater than in the case of the slow anti-apical meteors. For the low meteor of Sept. 22 the relative temperature would be only 110 against 1521 for the Perseid of Aug. 14. These circumstances may serve in a measure to explain the differences in the observed heights of the two meteors at combustion, though it is quite certain that slow-moving, as well as swift meteors, sometimes become incandescent at great elevations in the atmosphere.

Several large meteors have recently been seen by Mr. D. Booth at Leeds, but they do not appear to have been also observed elsewhere. On Sept. 15, $12^{\mathrm{h}}\ 30^{\mathrm{m}}$, a streak-leaving meteor, $= ♃$, passed from $25\frac{1}{2}^\circ + 38\frac{1}{2}^\circ$ to $1^\circ + 19^\circ$, and probably belonged to a shower near δ Aurigæ. At $12^{\mathrm{h}}\ 41^{\mathrm{m}}$ on the same night a meteor of similar brilliancy, though moving slowly, traversed a path from $74\frac{1}{2}^\circ + 44\frac{1}{2}^\circ$ to $86^\circ + 34^\circ$, and was directed from the radiant near δ Cephei. Its light exhibited four maxima and it left four short streaks along its course. On the morning of Sept. 20 two bright meteors, with long thick streaks and slowish motion, were recorded from a radiant at 88° + 19° in Orion. Several swift meteors were also registered from a well-defined radiant at 160° + 77½°.

At Theale, near Reading, on Oct. 1, about $9^h\ 55^m$, an immense meteor was seen by Mr. G. T. Davis shooting diagonally upwards into a large cloud about 15° above the horizon in the N.W. The meteor had a disk larger than the Moon, and gave a startling flash in spite of the diffused moonlight. Its position could not be fixed definitely, as there were no stars visible owing to the clouds and Moon. I have not heard that this large fireball has been seen at other places, and it is probable that cloudy skies obscured it from more general observation.

Errata.—'Observatory,' Dec. 1886, p. 394: the beginning-point of the fireball of Nov. 17, 1886, should be 52½° + 45° instead of 32½° + 45°. 'Observatory,' June 1887, p. 228: the path of the fireball of May 8, observed at Stafford, should be from 188¾° − 13½° to 186° − 25°. W. F. Denning.

Bristol, 1887, Oct. 4.

Selenographical Notes.

THE CENTRAL OBJECT ON THE FLOOR OF FRACASTORIUS.—Among the many features of a very diverse character which figure on the slightly convex interior of this interesting formation, the actual nature of that which occupies a nearly central position is very doubtful. If Fracastorius is observed when the rays of the rising sun first impinge on the floor, a low mound, associated with a short curved hill, is visible near the centre in a situation where, as the angle of illumination increases, objects of an apparently different type are gradually revealed; and as this angle diminishes, other features of a different character from those seen previously put in an appearance. An examination of a number of drawings made by competent observers brings to light puzzling anomalies which it will only be possible to reconcile when we possess the results of a systematic attempt to carefully delineate the feature in question under many more varied conditions.

I herewith append a selection from some observations of my own, made at different times, arranged in order from sunrise to sunset.

These records were all made under favourable atmospheric conditions, an excellent 4½ in. achromatic by the late Thos. Cooke, with a magnifying-power of 200, being used. One of the most curious circumstances in connection with them is the apparition of the prominent little crater under morning illumination

Date.	Long. of Terminator.	Appearance of Central Object.
883, Mar. 13 ...	Morng, 31° 10′ W....	A small curved hill with an oval elevation on the west of it, both casting distinct shadows. The two objects suggest the relics of a large central crater.
880, Dec. 6 ...	" 30 15 W....	A curved hill, with small round hill W.
873, Apr. 2 ...	" 28 21 W....	A distinct crater with two hillocks E.
881, Jan. 5 ...	" 27 0 W....	A very distinct crater filled with shadow. Nebulous spot W. of and touching it.
870, Sept. 30 ...	" 20 13 W....	A well-defined small hill, with a large nebulous spot adjoining it on the S.W.
881, Jan. 6 ...	" 14 50 W....	A distinct crater filled with shadow, situated on a light spur or projection from the east side of a large circular white spot on the west of it.
880, Nov. 8 ...	" 11 12 W....	A circular nebulous spot without visible details.
883, Mar. 15 ...	" 7 14 W....	A distinct crater filled with shadow, a large ill-defined light area adjoining it on the N.W.
873, Jan. 5 ...	" 7 10 W....	Two contiguous circular hills with a third oval-shaped hill trending in a S.E. direction from the more northerly. A small, but obvious, crater situated in the included angle.
870, Oct. 2 ...	" 5 10 E. ...	Two small ill-defined spots, the larger answering to little hill, the other (on S.W. side of it) to nebulous spot recorded on Sept. 30, 1870. On this occasion, however, the first-mentioned object appeared to be much the larger of the two.
80, Nov. 10 ...	" 13 9 E. ...	A bright triangular spot only.
70, Oct. 4 ...	" 30 0 E. ...	One large bright spot with a somewhat less bright semicircular area of equal size, joining it on the S.W.
70, Oct. 6 ...	" 55 26 E. ...	A large circular light spot with a smaller object of a similar type S.W. of it, but separated from it by a small interval.
70, Oct. 8 ...	" 78 19 E. ...	A circular bright spot, well-defined.
80, Dec. 15 ...	" 82 12 E. ...	Three minute bright spots standing on an ill-defined circular area.
80, Nov. 17 ...	Eveng, 81 20 W....	A bright spot with smaller bright spots on S. and E.
70, Oct. 10 ...	" 76 19 W....	Four small circular spots arranged in the form of a square.
70, Nov. 9 ...	" 70 28 W....	Three small bright specks arranged in the form of an equilateral triangle with its apex towards the N.
70, Oct. 11 ...	" 64 38 W....	As on October 4, 1870.
80, Dec. 18 ...	" 63 50 W....	Two minute bright points, with a nebulous spot adjoining them on the E., all of them standing on a light circular area.
83, Sept. 20 ...	" 37 29 W....	Two contiguous small hills, square shape, casting distinct shadows, with a large round hill adjoining them on the N.W.

when the W. long. of the terminat
quent disappearance, and its brief
light; while during evening illuminat
It seems consistent with the observat
object as being the remains of a larg
small crater in the midst of them, the
during a sinking sun representing pos
favourably placed for reflecting the Su
light.

Beer and Mädler draw a large oval
standing on the edge of a slight t
of Fracastorius in Mädler's 'Astron
small craters, and Lohrmann simply

Kempston, Beds, 1887, October 10.

CORRESPON

To the Editors of 'Th

The Rotation o

GENTLEMEN,—

With reference to this subject,
contained in my article on Algol ('O
are likely to convey an exaggerated
from the star's axial rotation.

On the probable assumptions tha
and that the plane of its equator does
of its orbit*, it is demonstrable that
(more especially) the *shading* of t
spectrum would occur whilst the part
in progress. A close examination s
probable supposition as to the rat
changes would be *quite inconspicuo*
possibly be detected with the aid of
the finest atmospheric conditions. A
graphs of Algol's spectrum would pr
of bringing to light such delicate vari

A knowledge of the rate at which
would be of considerable interest fro
especially when taken in connectio
researches on tidal friction. The
information on this point would see
notice.

St. Catharine's, Ont., Canada,
1887, Sept. 29.

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* Through inadvertence, this condition w

Pritchard's Photometer.

GENTLEMEN,—

In your last issue you noticed an investigation by Prof. Pickering of a Pritchard's photometer. Inasmuch as I have used a slightly modified form of this instrument for the last twelve months and have carried out nearly three thousand extinctions, perhaps the following remarks by way of relating my personal experiences with the instrument will not be out of place and may possibly interest some of your readers. They are divided into two heads, concerning the instrument and its application.

The Photometer.—Prof. Young rightly calls attention to the difficulty of keeping the eye in a suitable position to receive the emergent ray, and the annoyance he felt at the movable portion (the wedge-plate itself) knocking against the nose from the close proximity of the observer—a position he must take to prevent the eye slipping off the eye-hole. This was experienced to such a degree, that an additional eye-hole was arranged and mounted on a tube about half an inch in length, being itself affixed to the eye-hole already provided by the maker. The convenience of this arrangement must be used to be fully appreciated. In addition, the arrangement of the photometer designed by Sir Howard Grubb has this difference—the whole wedge with its slow motion lifts on a hinge, instead of the wedge *itself* only drawing out, thus allowing the observer to look at the object under consideration whenever he desires without disturbing the technical reading of the wedge. At times this may be very convenient—in case, for instance, of a cloud passing over the object, or the shifting of a star from the centre of the field by some wave in the motion of the driving-clock of the telescope.

In place of revolving lenses and diaphragm, the wedge is mounted on the occulting eyepiece ('Monthly Notices,' Vol. xlv. p. 91), which is of great convenience, as it enables the observer to blot out with the occulting shutters any offending luminary and yet allows him a reasonably sized field, thus removing another of the objections of Prof. Young. In the case of double stars, too, the affixation of the occulting eyepiece affords an opportunity—by moving the shutters to and fro—of noticing whether any subjective influence has been produced by the presence of a second bright object in the field (see the 'Harvard Annals,' 1878–79, and the Memoir on the wedge by Prof. Pritchard). The two different oculars provided with the occulting eyepiece can each be used with the wedge, but the one mostly employed was that which magnified about 180 diameters. The graduations are to half inches (instead of whole ones as in the Oxford instrument), and the whole apparatus can be revolved on its axis independently of the draw-tube of the telescope.

Its application.—The instrument was treated as a new one, and consequently carefully learnt, a process that took nearly three months, for the following reasons :—

1st. Considerable practice is required to keep the eye from slipping off the eye-hole even with its tube lengthened, which accident, it is needless to state, causes an extinction to be recorded, which is valueless.

2ndly. It takes much time and perseverance attaining the necessary experience to judge of the rate at which an extinction is to be made. If too fast, the sensuous impression on the retina will be so completely retained, that over-wedging will unquestionably result: if too slow, neglecting for the present moment the fatigue caused by keeping the hand uplifted so long, the eye will weary with the prolonged strain, and the result will probably be inaccurate. That this knowledge can be obtained it is needless to state, but my progress was very slow, so much so that at the end of the first six weeks I began to be doubtful whether some personal subjective influence might not be inducing a form of error over which I had no control.

These experiences lead me to think that Prof. Young is correct in assuming that a portion of his errors arise from too short an experience with the instrument. That accurate results can be obtained otherwise than by dint of such enormous experience as that of Messrs. Plummer and Jenkins of Oxford, is afforded by the following table, in which two sets of observations were taken at five months' interval, and, although made whilst engaged on different subjects, the object was the same in each case, viz. to ascertain the loss in magnitude resulting from the use of a certain diaphragm.

	April 30.				*October* 11.	
	Polaris.		δ Leonis.		Polaris.	
	Full.	Reduced.	Full.	Reduced.	Full.	Reduced.
	8·06	1·47	7·26	0·61	8·10	1·06
	7·80	1·18	7·80	0·49	8·30	0·83
	8·24	1·18	7·63	0·53	7·85	1·10
	8·10	1·03	7·60	0·62	7·99	0·95
	7·91	1·17	7·38	0·65	7·50	0·92
	7·82	0·94				
	8·04	0·98				
	8·01	0·95				
	8·17	1·11				
	8·23	1·09				
Mean	8·038	1·100	7·534	0·58	Mean. 7·948	0·972

Although the actual figures obtained (which must be divided by 2 to compare with the errors in the Oxford wedges) are so different, still the intervals between the resulting means are almost identical, being 6·938 for the first; 6·954 for the second; 6·976 for the third, taken several months after. Reduced to magnitude these become 4·93, 4·95, and 4·98 respectively.

The average deviations of the wedge intervals from their mean in the first column is ·179; in the second ·056; in the third ·122;

in the fourth ·128; in the fifth 0·218; and in the last 0·086, which, converted into magnitude, become, respectively, ·13, ·04, ·08, ·09, ·15, ·06.

In conclusion, I agree with Prof. Young that the use of this form of photometer is fatiguing, and that temporary hemiopsia frequently results. It is best avoided by the observer gently rubbing and pressing his eyes whilst looking at the heavens for a short time between each observation.

Ivy House, Clapham Common, S.W.
1887, October.

Yours faithfully,
EDMUND J. SPITTA.

OΣ 256.

GENTLEMEN,—

The phenomena attending the occultation of this double star here, on the evening of August 22nd last, appear to confirm the suspicion entertained as to the variability of one of its components. As the Moon was hidden from the large equatorial by the roof of the main observatory, it was found necessary to observe the disappearance with the 4½-inch telescope, and a power of 80 was employed for the observation. The star, which at the time had not been identified and was not suspected to be double, was followed quite up to the Moon's dark limb, which was beautifully distinct. At $17^{h}\ 17^{m}\ 25^{s}.8$, sidereal time, fully three-fourths of the star's light suddenly disappeared, and four half-seconds of the chronometer later the rest of its light, which resembled a blurred star of the 9th magnitude, vanished quite as suddenly. It would appear from this observation that the preceding star was the brighter; whereas the recent measures in Crossley, Gledhill, and Wilson's 'Handbook of Double Stars' represents this component as the companion. The 'Handbook' also states that one of the components is probably a variable. Cloudy weather has since intervened, and the object being now low, I am unable to examine it with a high power on the large equatoreal.

Windsor, N. S. Wales,
1887, Sept. 6th.

Yours faithfully,
JOHN TEBBUTT.

The Periods of the Planets.

GENTLEMEN,—

I read with much interest, in the last number of the 'Observatory,' a note by Mr. Monck, showing some very simple and remarkable numerical relations between the sidereal revolutions of the planets of the solar system. But Mr. Monck starts from an entirely arbitrary supposition, whilst I have shown (Comptes Rendus, Tome xcvii. 1883, Aug. 27) that the orbits of planets must be the development of the solar rotation, and therefore the times of the sidereal revolutions of the planets must be multiples of the time taken by the Sun to perform half a rotation on its axis, or for a point on its surface to pass through 180°.

Taking as an example the Earth, R, the time of the sidereal revolution, = 365·256 days. Dividing by 29 we get

$$\frac{T}{2}=12{\cdot}59505 \text{ days},$$

or T, the time of the solar rotation, = 25·19010 days.

Faye, from a discussion of all the known observations of sun-spots, has found T = 25·18689 days. There is therefore only a difference of 0·00321 days between the observed and calculated durations of the Sun's rotation.

The following Table gives the observed sidereal revolutions for each planet as compared with the sidereal revolutions calculated by the following formula:—

$$N\times\frac{T}{2}=12^{d}{\cdot}593444\times N=R.$$

Planet.	N.	Diff.	Sidereal Revolution.		Difference.
			Observed.	Computed.	O−C.
			d	d	d
Mercury ..	7*		87·97	88·15	−0·18
Venus	18*	11	244·70	226·68	−1·98
Earth	29*	11	365·256	365·210	+0·046
Mars	55*	26	686·98	692·64	−5·70
Jupiter ..	344	289	4332.59	4332·26	+0·23
Saturn....	854	510	10759·24	10754·79	+4·45
Uranus ..	2437	1583	30688·39	30690·22	−1·83
Neptune ..	4779	2342	60181·11	60184·07	−2·96

The same law holds good in the case of periodical comets and periodical meteor-showers, as I have shown (Comptes Rendus, March 1883); and if the rotation of the central body be the real cause of revolution of the smaller bodies revolving round it, the same law must hold good for the secondary systems of Jupiter, Saturn, and Uranus.

The Earth representing the central body for our Moon, the Moon's sidereal revolution, $27^{d}{\cdot}3216$, is almost exactly 55 the Earth's half-rotation, $12^{h}\times 55=27^{d}{\cdot}5$, the difference between the calculated and observed values being only $0^{d}{\cdot}1784$. Prof. Newcomb has kindly sent me his celebrated work on Eclipses, in which he gives the value of the lunar cycle, the Saros, as $6585^{d}{\cdot}3122$. Multiplying $12^{d}{\cdot}593444$ by 523 we get 6586·3712, with a difference from the Saros of only $1^{d}{\cdot}0590$, or 0·015 per cent. of the whole. But 523 = 18 × 29 + 1, or the Saros is equal to 18 years and one half-rotation of the Sun—a most interesting relation between the motions of the Moon, the Earth, and the Sun.

The following tables give the data for the other secondary systems in the same form as in the first table, and likewise show very close coincidences between the observed and computed sidereal revolutions of the satellites:—

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* Identical with Mr. Monck's formula.

I. The Jovian System : $\frac{T}{2}=4^{h}\ 57^{m}\ 48^{s}{\cdot}5$.

Satellite.	N.	Sidereal Revolution. Observed.			Sidereal Revolution. Computed.			Difference. O—C.		
		h	m	s	h	m	s	h	m	s
I	9	42	27	33·51	44	40	16·5	−2	12	42·99
II	17	85	13	42·05	84	22	44·5	+0	50	58·55
III	35	171	42	33·99	173	43	17·5	−2	0	43·51
IV	81	400	32	11·20	402	2	28·5	−1	30	17·30

The largest difference being 5 per cent. for the first satellite; and the smallest difference being 0·4 per cent. for the fourth.

II. The Saturnian System : $\frac{T}{2}=5^{h}\ 7^{m}\ 12^{s}$.

Satellite.	N.	Sidereal Revolution. Observed.			Sidereal Revolution. Computed.			Difference. O—C.		
		h	m	s	h	m	s	h	m	s
Mimas	4	22	57	5·4	20	28	48	+2	21	17·4
Enceladus	6	32	53	6·9	30	43	12	+2	9	54·9
Tethys	9	45	18	25·6	46	4	48	−0	46	22·4
Dione	13	64	41	9·3	66	33	36	−0	52	26·7
Rhea	21	108	25	11·6	107	31	12	−0	53	59·6
Titan	75	382	41	23·2	384	0	0	−1	18	36·8
Hyperion	100	510	39	27·0	512	0	0	−1	20	33·0
Iapetus	372	1903	54	17·0	1904	38	24	−0	44	7·0

The differences are still less for the outermost satellite than in the Jovian System, being only 0·03 per cent. for the revolution of Iapetus.

III. The Uranian System : $\frac{T}{2}=5^{h}{\cdot}984$.

Satellite.	N.	Sidereal Revolution. Observed.	Sidereal Revolution. Computed.	Difference. O—C.
		h	h	h
Ariel	10	60·50	59·84	−0·66
Umbriel	17	99·45	101·73	−2·28
Titania	35	208·95	209·44	−0·49
Oberon	54	323·15	323·36	−0·21

Here also the smallest difference is found with the outermost satellite, Oberon, for which it is only 0·07 per cent.

IV. Neptunian System.

In the case of Neptune, we have no indication of its rotation period, except from the photometric observations of Maxwell Hall in Jamaica, who has inferred from a periodic change in the luminosity of the planet's disk that it has a rotation period of $7^{h}{\cdot}92$; from whence $\frac{T}{2}=3^{h}{\cdot}96$. The sidereal revolution, R, of the satellite of Neptune being $141^{h}\,2^{m}\,44^{s}{\cdot}2$, we get

$$\frac{141^{h}{\cdot}455}{3{\cdot}96}=35{\cdot}74.$$

Taking 36, the nearest whole number, as the number of multiples, and dividing the time of revolution, we get

$$\frac{T}{2}=\frac{141^{h}{\cdot}455}{36}=3^{h}{\cdot}9294,$$

a little smaller than Hall's observations give.

From the close accordance of the calculated and observed revolution-times it would appear that the law I have discovered is a general one; and the supposition of the late Director Bruhns is confirmed that the close approximation of such simple relations as astronomers have found between the angular elements and the revolution periods of the planets, such as Gauss, for instance, found for Pallas and Jupiter, are not due to chance and are not to be considered as mere curious coincidences, but as really expressing a general law governing the entire solar system. It is clear that the law of multiple half-rotations in the periodic times of the planets implies that commensurability of their sidereal revolutions supposed by Gauss, and which may be expressed by a large number of special numerical relations amongst the planets and their satellites.

For instance, in the Jovian system we find the following multiples:—

$$9,\quad 17,\quad 35,\quad 81,$$

whose differences are

$$\begin{array}{ccccc} 8, & & 18, & & 46, \\ & 10, & & 28, & \\ & & 18, & & \end{array}$$

and $9\times\mathrm{I}=81=\mathrm{IV}$, and $2\times\mathrm{I}+\mathrm{II}=35=\mathrm{III}$.

Similarly, in the Saturnian system the four inner satellites give a series of multiples as follows:—

$$\begin{array}{ccccccc} 4, & & 6, & & 9, & & 13, \\ & 2, & & 3, & & 4, & \\ & & 1, & & 1, & & \end{array}$$

and a large number of relations may be formed.

$3\times\ \mathrm{I}=12=2\times\mathrm{II}$; $3\times\mathrm{I}+\mathrm{II}=18=2\times\mathrm{III}$;
$3\times\mathrm{II}=18=2\times\mathrm{III}$; $\mathrm{I}+\mathrm{III}=13=\mathrm{IV}$;
$7\times\mathrm{III}=63=3\times\mathrm{V}$; $16\times\mathrm{II}=96=\mathrm{V}+\mathrm{VI}$;
$3\times\mathrm{VII}=300=4\times\mathrm{VI}$; $62\times\mathrm{II}=\mathrm{VIII}$.

In the Uranian system we get likewise:—

$6(\mathrm{I}+\mathrm{III})=270=5\times\mathrm{IV}$; $5\times\mathrm{II}=85=5\times\mathrm{I}+\mathrm{III}$;
$3\times\mathrm{III}=105=3\times\mathrm{II}+\mathrm{IV}$; $7\times\mathrm{I}=70=2\times\mathrm{III}$.

The series formed by the multiples of solar half-rotations for the inner planets Mercury, Venus, and the Earth,

$$7, \quad 18, \quad 29,$$

may be represented by a formula very similar to Bode's well-known law:—

$$7 = 1 \times 4 + 1 \times 3;$$
$$18 = 3 \times 4 + 2 \times 3;$$
$$29 = 5 \times 4 + 3 \times 3.$$

This series has no conceivable continuation upwards, and no body is as yet known to fill in any way the interval between the Earth and Mars. It seems therefore improbable that more planets will be found between Mercury and the Sun or between the Earth and Mars. In my work, 'The Meteorology of the Sun and its System,' I have tried to show that the contrary is the case with the group of minor planets, for which there is a large number of multiples still outstanding between the lowest and highest number of multiples corresponding to the sidereal revolutions of the nearest and furthest planetoids from the Sun as yet known.

Yours truly,
Meran, 1887, Sept. 17. Ch. V. Zenger.

[We fear that Prof. Zenger's figures are less convincing than he thinks. His residuals should surely have been compared, not with R, but with $\frac{T}{2}$. It is clear that if any two numbers be taken, however wholly unconnected, the remainder, when the first is divided by the second, cannot exceed half the divisor. But Prof. Zenger's residuals frequently approach $\frac{T}{4}$, and on the average are not very different from $\frac{T}{8}$, as should be the case if R and $\frac{T}{2}$ were two wholly independent quantities.—Editors.]

NOTES.

New Variable Stars.—The Rev. T. E. Espin sends us the annexed particulars respecting the following new variable stars:—

	D.M.	R.A. 1885.	Decl.	Variation.		Per^{d}.	1888.
		h m	° ′	Max.	Min.	days.	Max.
V. Cassiop.	+47° No. 194	0 39·55	+47 37·6	8·5	14·0	260±	May 1
* Tauri...	....	4 21·25	+15 50·7	8·2	13·0	360±	Mar. 17‡
Aquilæ	+8° No. 3780	18 32·52	+8 43·5	6·5	9·0	310±	Feb. 18
† Cygnus	....	....	....	7·1	14·0		

* Vogel (Astron. Obs. zu Potsdam, ii.) No. 594.
† Dun-Echt Circular, No. 143, 19^{h} 58^{m} 15^{s}·28, +49° 43′ 40″·4, 1887.0.
‡ Min. 1888 Sept. 16.

THE LATE PROF. KIRCHHOFF.—The
of Prof. Gustav Robert Kirchhoff depri
of the investigator to whom it chiefl
name will ever be most readily rememb
connection with it; for though Kirchho
are but a portion of his work for science,
were engaged in the same field both bef
time, it was the publication of these
great work on the solar spectrum, wh
attention of the scientific world to spe
out fresh and unhoped-for possibilities

Prof. Kirchhoff was 63 years of age
having been born on March 12, 1824
Extraordinary Professor in Breslau fro
fessor of Physics at the University of
1874. Whilst here he sustained a serio
affected his health, and eventually incap
1874 he became Physical Professor at t

THE PULKOWA CATALOGUE OF 3542
Backlund * has compared the star-pla
those of the other existing Pulkowa
Herr Romberg's as yet unpublished ca
from observations made with the Merid
1874–1880, as well as with the catalogu
Boss. Remarking that the places of t
independent ('Observatory,' Vol. ix. p
comparisons show that, at all events in
astronomers as are those attached to
the problem of the determination of the
can be very satisfactorily solved, but tha
of absolute positions is in a very di
Pulkowa determinations of the Equi
and 1865 differ by as much as o
Æquinoctum für 1865·0'). And
declinations of the Pulkowa Catalogu
Boss's Standard Catalogue shows the
Pulkowa positions for stars south of the
finds that the probable error of a R.A
for Dec. 60° to 30°, $\pm 0''{\cdot}048$, and for D
and that the probable error of a declinat

Herr Seyboth † has also compared
Catalogue for 1855 with those of the Ca
agreement being very satisfactory consi

---

[*] Mélanges Mathématiques et Astronomiqu
Impériale de St. Pétersbourg, Tome vi. pp. 563

[†] Astronomische Nachrichten, No. 2808.

pendent character of the results, except for those stars which are unfavourably placed for observation at either observatory. From a comparison of the places of the fundamental stars only, Herr Seyboth finds for the probable error of a difference in R.A. and declination $\pm 0^{s}\cdot029$ and $\pm 0''\cdot41$ respectively; and taking the probable errors of the Pulkowa places to be in R.A. $\pm 0^{s}\cdot020$ and in declination $\pm 0''\cdot15$, there results for the probable errors of the Cape Catalogue places $\pm 0^{s}\cdot021$ and $\pm 0''\cdot38$ in R.A. and declination respectively.

Publications of the Washburn Observatory.—It will be remembered that Prof. Holden left the Washburn Observatory in the winter of 1885, to assume the directorship of the Lick Observatory and the presidency of the University of California. Prof. Davies, of the University of Wisconsin, has had temporary charge of the Observatory pending the appointment of Prof. Holden's successor, and, of course, has only been able to give to it such time and general attention as were compatible with the efficient discharge of his other duties. Under these circumstances, it is not surprising that no new work of any magnitude has been undertaken since the completion of the 303 star-list for the 'Astronomische Gesellschaft,' which was planned and nearly completed by Prof. Holden. The volume before us, No. V. of the Publications of the Washburn Observatory, contains the record of the work done chiefly during the year ending April 1887, which, with the meridian-circle, was almost entirely confined to an elaborate investigation of the latitude, of the instrumental errors of the instrument, and of refraction; whilst with the equatoreal, observations of double stars, of Sappho, and of Comet *b*, 1887 (Brooks), were obtained. An index of stars in Airy's six Greenwich Catalogues not found in Flamsteed has been prepared by Miss Lamb, one of the observatory assistants. This index forms a considerable part of the volume, and has been prepared according to the general plan suggested by Argelander (V. J. S. Bd. vi. Heft 2), the object being to save the computer the labour of looking through all the catalogues when searching for a star which is tolerably sure to be in one of them. In the case of Flamsteed's stars, this labour is so seldom required that it seems unnecessary to include them. Miss Lamb's paper, which contains references to some 3000 stars, is one which will be very useful to the practical astronomer. The promptitude with which this volume has been printed and published deserves a word of commendation: it is in marked contrast to what obtains in some—indeed in most—other observatories.

Southern Double Stars.—In the 'Monthly Notices' for June 1887 some measures of double stars recently made at the Sydney Observatory are published. A good deal of attention has, of course, been paid to α Centauri, the mean of 22 measures and its comparison with places computed from (I.) Downing's Orbit (period =76 years) and (II.) Powell's Orbit (period =87 years), as given by Mr. Powell in 'Monthly Notices,' April 1886, page 340, being as follows:—

	Epoch.	Angle.	Distance.
Observed	1886·495	202°·05	15″·01
Computed (I.) ..	1886·275	202 ·61	14 ·89
" (II.) ..	1886·275	201 ·74	15 ·04

It evidently will not be possible to decide which of these periods is the more correct for some years to come.

Another interesting object which has been measured several times at Sydney is γ Coronæ Australis. The most satisfactory orbit of this binary hitherto published appears to be that of Mr. Gore ('Monthly Notices,' Jan. 1886), the time of periastron passage given in which falls very near the mean epoch of the Sydney measures, as the following comparison shows:—

	Epoch.	Angle.	Distance.
Observed	1886·615	200°·59	1″·45
Computed	1886·53 [=T]	196 ·7	1 ·13

These Sydney measures and those made by Messrs. Stone and Wilson at Cincinnati, in 1881 and 1883, published in the 'Observatory,' Vol ix. page 234, are, so far as we know, the only observations of γ Coronæ Australis which have been put on record since the publication of Mr. Gore's orbit. It is possible, however, that other observations may have been made during this period, and, if so, we hope that they will be published without unnecessary delay. At all events we trust that astronomers who are favourably situated for observing this double star will not neglect to do so during the present critical period of its history.

THE DEARBORN OBSERVATORY.—Prof. Hough's Report for the two years ending May 1887 has been received. During this period, as heretofore, standard time has been furnished to the city of Chicago and the Board of Trade. Meridian observations for time have been made whenever practicable; on the average there has been a time determination every two days. The work with the great equatoreal, as in former years, has been confined to difficult double stars, the planet Jupiter, and some miscellaneous observations. During the two years to which the Report refers, Prof Hough (who appears to be now working single-handed) has discovered and measured 130 new double stars, the majority being difficult objects, and a considerable number of which will prove interesting, owing to the closeness of the components, 45 of them having a distance less than 0″·5 and 11 having a distance between 0″·5 and 1″·0, whilst the remainder belong to the class of stars having very minute companions. The companion to Sirius has been measured on 12 nights in 1886 and 7 nights in 1887, with mean results: 1886·144, angle$=28^\circ\cdot7$, distance$=7''\cdot21$; 1887·195, angle$=23^\circ\cdot7$, distance$=6''\cdot78$. The planet Jupiter has been systematically observed, with special reference to the great Red Spot. The ring-form of the spot has continued up to the present time, though its colour has changed materially from year to year, and during the last three years Prof. Hough has at times found it to be so faint as to be scarcely visible. Four sketches of the planet, exhibiting the salient features seen on the disc on 1886, March 5 and 6, May 2 and 7, are reproduced in the Report. Other observations which have been made with the equatoreal are measures of the relative position of the Nova in Andromeda and the nucleus of the nebula (the mean result for 1885·740 being, angle$=250^\circ\cdot7$, distance$=15''\cdot86$), observations of Saturn, of Comets, and photographs of the Moon, including photographs of the partial eclipse of the Moon on September 23, 1885. The appendices to the Report include a catalogue of 209 new double stars discovered by Prof. Hough, also published in the 'Astronomische Nachrichten,' Nos. 2778–9, a catalogue of Nebulæ found at the Dearborn Observatory 1866–8 by Prof. Safford, containing 108 entries, and the description of Hough's printing chronograph, reprinted from the 'Sidereal Messenger' (Observatory,' Vol. viii. p. 442.)

THE LATE JOSEPH BAXENDELL, F.R.S.—We greatly regret to have to record the death of Mr. Joseph Baxendell, Senior, which took place at the Observatory, Birkdale, Southport, on Friday, Oct. 7, after much severe suffering. Mr. Baxendell was born in Manchester in 1815. He had but moderate educational advantages in his youth, but his perseverance and desire for knowledge enabled him to overcome all difficulties, and he acquired a considerable acquaintance with mathematics, which was of especial service to him in the two sciences Astronomy (to which he had been devoted from early childhood) and Meteorology (to the pursuit of which the years he passed in a seafaring life had attracted him). Mr. Baxendell's principal original researches lay chiefly within the domains of the two sciences and of Sanitary Science, though he was also the author of a large number of papers and memoirs relating to other branches of science. He contributed twelve papers to the 'Monthly Notices' of the R.A.S., sixteen to the 'Memoirs of the Manchester Lit. and Phil. Society,' and forty-seven to the 'Proceedings,' and numerous others to the 'Astronomische Nachrichten' and various English and American journals; and for some years prior to his death he frequently published articles in the 'Observatory.' He was the discoverer of eighteen new variable and temporary stars; and the variability of many of the former was ascertained from observations he made with reflecting telescopes, the speculæ of which he had himself cast, ground, and polished. In 1884 he was elected a Fellow of the Royal Society, an honour entirely unsought, and therefore doubly valued by him in his declining years. He was likewise a Fellow of the Royal Astronomical Society and corresponding member of the Royal Society of Königsberg, and of the Scientific and Literary Academy of Palermo, On the death of the Rev. H. H. Jones in 1859, he was appointed Astronomer to the Manchester Corporation.

NEW MINOR PLANETS.—A new minor planet, No. 270, was discovered by Dr. C. H. F. Peters, of Clinton, on Oct. 8. This is the 47th discovered by this observer. Another planet, No. 271, was discovered on Oct. 16 by Dr. Knorre, at Berlin, being his fourth discovery.

Elements and Ephemeris of Olbers' Comet, 1887 *.

By O. TETENS.

T=1887 Oct. 8·4938, Berlin M.T.

π	149° 48′ 7″	Mean Eq. 1887·0.
☊	84 27 40	
i	44 32 53	
ϕ	68 35 36	
log q	0·078899	

$$x=[9{\cdot}854835]r\sin(v+237^\circ\ 35'\ 31'').$$
$$y=[9{\cdot}972351]r\sin(v+168\ \ 39\ \ 22\ ).$$
$$z=[9{\cdot}891623]r\sin(v+\ 95\ \ 54\ \ \ 3\ ).$$

Ephemeris for Berlin Midnight.

1887.	R.A. h	m	s	Decl. °	′	Log r.	Log Δ.	Brightness.
Oct. 30..	13	39	39	+18	29·4	0·0950	0·2875	1·42
Nov. 1..	13	47	30	17	44·1			
3..	13	55	10	16	58·8	0·1010	0·2924	1·35
5..	14	2	41	16	13·5			
7..	14	10	2	15	28·3	0·1077	0·2979	1·28
9..	14	17	13	14	43·5			
11..	14	24	15	13	59·0	0·1152	0·3037	1·20
13..	14	31	8	13	15·0			
15..	14	37	51	12	31·6	0·1232	0·3098	1·12
17..	14	44	25	11	48·9			
19..	14	50	51	11	6·7	0·1317	0·3162	1·05
21..	14	57	9	10	25·3			
23..	15	3	18	9	44·7	0·1406	0·3226	0·98
25..	15	9	20	9	5·0			
27..	15	15	12	+ 8	26·0	0·1499	0·3291	0·91

The brightness on Aug. 27 is taken as unity.

---

* Astron. Nachr. No. 2806.

ERRATUM IN VOL. IX.

Page 343, line 5 from foot, *for* 1884 *read* 1885.

No. 130.] DECEMBER, 1887. [*Price* 1*s*.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

E. W. MAUNDER, F.R.A.S.,
A. M. W. DOWNING, M.A., F.R.A.S.,
AND T. LEWIS, F.R.A.S.

10

CONTENTS.

Titlepage and Index to Vol. X. PAGE
Meeting of the Royal Astronomical Society on November 11 401
Meeting of the Liverpool Astronomical Society 410
La Société Astronomique de France 412

Articles:—

The Rejection of Discordant Observations. By ASAPH HALL, For. Assoc. R.A.S. 414
Meteor Notes. By W. F. DENNING, F.R.A.S. 417
Selenographical Notes. By T. G. ELGER, F.R.A.S 419
The Bibliography of Astronomy. By E. W. MAUNDER, F.R.A.S. 421

Correspondence:—

The Length of the Saros. By Capt. WILLIAM NOBLE, F.R.A.S. 423
The Variable Star Algol. By J. M. BARR and W. H. S. MONCK, M.A., F.R.A.S 423, 425
The Periods of the Planets and Satellites. By W. H. S. MONCK, M.A., F.R.A.S. 425
Drilling small Holes. By EDMUND J. SPITTA, F.R.A.S. 426
Break-circuit Chronometers. By R. L. J. ELLERY, F.R.S. 427
Lalande 26481. By Prof. T. H. SAFFORD, For. Assoc. R.A.S. 428
Birmingham 121 Tauri *alias* Geminorum. By T. W. BACKHOUSE, F.R.A.S. ... 429

Notes:—

Researches on the Spectra of Meteorites.—The Rotation of Jupiter.—American Observatories.—The late Dr. E. Luther.—Parallax of Σ 2398.—The Orbit of the Binary Star Σ 3121.—Bevis's Star Atlas.—The Spectra of Oxygen and Carbon compared with that of the Sun.—New Variable in Libra.—The Variable Star, U Ophiuchi.—The two new Algol-variables Y Cygni and R Canis Majoris.—The Natal Observatory.—Proper Motions of Stars.—The Council of the R.A.S.—The late Dr. H. C. F. C. Schjellerup.—Probable New Class of Variable Stars.—Names of Minor Planets . 429–439

Ephemeris for Olbers' Comet. By O. TETENS 439
Editorial Note 440

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CONTENTS OF No. 129.

PAGE
Meeting of the Liverpool Astronomical Society 369

Articles:—

The Total Eclipse in Japan. By David P. Todd, F.R.A.S. 371
Airy's Numerical Lunar Theory. By M. R. Radau 377
Meteor Notes. By W. F. Denning, F.R.A.S. 384
Selenographical Notes. By T. G. Elger, F.R.A.S. 386

Correspondence:—

The Rotation of Algol. By J. M. Barr 388
Pritchard's Photometer. By Edmund J. Spitta, F.R.A.S. 389
OΣ 256. By John Tebbutt, F.R.A.S. 391
The Periods of the Planets. By Prof. Ch. V. Zenger 391

Notes:—

New Variable Stars.—The late Prof. Kirchhoff.—The Pulkowa Catalogue of 3542 Stars for 1855.—Publications of the Washburn Observatory.—Southern Double Stars.—The Dearborn Observatory.—The late Joseph Baxendell, F.R.S.—New Minor Planets 395-400

Elements and Ephemeris for Olbers' Comet, 1887. By O. Tetens 400

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THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 130. DECEMBER. 1887.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, November 11, 1887.

J. W. L. Glaisher, M.A., F.R.S., *President*, in the Chair.

Secretaries: E. B. Knobel and
Lieut.-Col. G. L. Tupman.

Col. Tupman announced that 174 presents had been received since the last Meeting; amongst them the Report of the Transit of Venus, 1882, and the voluminous report of the German observations. From Dr. Stroobant we have a brochure in which he discusses all the recorded observations of the supposed satellite of Venus. He shows clearly that in nearly every case the observations can be explained by the presence of stars. There is from Admiral Mouchez the report of the Photographic Conference. We have also part of the first volume of Messrs. Houzeau and Lancaster's 'Bibliographie Générale d'Astronomie,' and from Dr. Gould vol. vii. of the Cordoba Observations. Our Fellow, Mr. Roberts, has presented some more photographs.

A vote of thanks was voted to the donors.

Mr. Knobel said that on the occasion of presenting an address to the Queen, the opportunity was taken of asking her Majesty to sign our book as Patron of the Society. He had much pleasure in announcing that the Queen graciously complied with the request. The book was exhibited to the Meeting.

The President then read two letters, one from Mr. Isaac Roberts offering to supply, to any Fellows of the Society, such photographic negatives as would enable them, with the aid of a micrometer and microscope, to obtain valuable astronomical information on stellar parallax, &c., without having to expose themselves to the weather.

He merely stipulated that the results should be presented to the Meeting in a form acceptable to the Council. The other letter (from Admiral Ryder) was as follows:—

Memorial to the late Admiral Sir C. F. Shadwell, K.C.B.

Wellswood House, Torquay,
Sept. 26, 1887.

The Secretary of the Royal Astronomical Society.

Sir,—I have been requested by the Committee (of which I am Chairman) for carrying out the above object, to inform you that with the cordial approval of the Lords Commissioners of the Admiralty, who will request the Hydrographer to award the prize annually, a fund is being raised with the object of perpetuating the memory of the late Admiral Sir C. F. Shadwell, K.C.B., by an annual prize consisting of Marine Surveying Instruments, to be offered for the most useful Marine Survey carried out and "projected" by an officer of not higher rank than Lieutenant while employed on the *General* Service—not the *Marine* Surveying Service.

Admiral Sir C. F. Shadwell was distinguished in the Royal Navy in many ways—for gallantry and all officer-like qualities, and especially for his devotion to Marine Surveying and Nautical Astronomy, on which latter subject he published a most valuable series of books.

Our Committee are under the impression that the Members of the Royal Astronomical Society might like to be afforded an opportunity of aiding our object, which, if liberally supported, will connect Sir C. F. Shadwell's name with an effort to encourage young officers to become good practical Marine Surveyors, with which must necessarily be combined a sound knowledge of Nautical *Astronomy*. We have received £100, and hope to increase the fund to £1000, the interest of which will be sufficient.

I am, your obedient Servant,
Alfred P. Ryder,
Admiral of the Fleet.

P.S.—The Rev. J. B. Harbord, Chaplain of the Fleet, is our Hon. Secretary, and our Bankers are Drummond & Co.

Dr. E. J. Spitta read a paper on the appearances presented by the satellites of Jupiter during transit, with a photometric estimation of their relative albedoes and of the amount of light reflected from different portions of an unpolished sphere.

He observed that since the discovery of the satellites in 1610, astronomers had been puzzled by the behaviour of these objects, and the present paper was restricted to the appearances presented by the satellites, more especially in transit. These appearances were summarized as follows:—The 4th was fainter than the others on approaching the limb of the planet; bright for the first ten or fifteen minutes of transit, lost for about the same time, reappearing as a dark spot. The 3rd was sometimes lost, then again appearing as a dark spot; at other times it remained white during the whole of the transit. Maraldi saw both appearances as far back as 1707, and these in the same month. The 2nd was always bright during transit, its brilliancy being least affected on approaching contact. The 1st after becoming lost usually turned one of the shades of grey to black.

Attention was called to the peculiarity of the second satellite, but the statement was true, for in all the unpublished observations which he had received in reply to a special request, no abnormalities were forthcoming concerning this satellite. At first it was hoped the occulting eyepiece, already shown to the Society, would prove of use in cutting off the background of Jupiter, but diffraction phenomena prevented its use when the shutters were sufficiently closed.

In 1886 it was thought that experiments on the effects of contrast might be carried out to ascertain the proportions of light which two bodies must possess, so that the smaller should appear grey or black when superimposed on the larger, and it was also hoped that if the facts and figures thus experimentally obtained corresponded with the albedoes of the satellites themselves as compared with Jupiter, it would be not unreasonable to suspect that the abnormal appearances presented by the real satellites depended on functional idiosyncrasies of the eye itself, rather than upon physical peculiarities of the Jovian system. Time would not allow him to describe in detail the experiments which he had made, and he hoped that if his remarks appeared somewhat disjointed, due allowance would be made. It was not easy to epitomize them.

Small disks of different tintings with Indian ink, representing the satellites, were superimposed on larger ones of various sizes of pure white cardboard, and it was found that, with certain restrictions, the difference in albedo between the smaller and the larger caused the grey and black appearances, and that they were not due to any difference in the quantity of light reflected by either. For a moon to appear grey or black, a difference in albedo was required of ·42 in the first case, and of ·87 in the second, whilst moons of a superior albedo remained white during transit. Further, the effect of one moon approaching another was gone into, and the fading of the smaller was likewise found to be in direct proportion to the relation its albedo bore to that of the greater, and in no way connected with the amount of light reflected by either. The effects on the appearances of the same little moons when in transit over different portions of a sphere were also studied, and strange as it may seem, the whole of the phenomena of a dark transit was completely reproduced, and this caused much surprise, seeing it was brought about by such simple means. The concluding experiments consisted in photometrically ascertaining for the first time the reflective ability of different portions of an unpolished sphere by two methods, both giving very accordant results.

The method of obtaining the albedoes was then alluded to, for much difficulty had been experienced owing to, first, the ascertaining of the amount of light lost in the use of a certain diaphragm necessarily employed in wedging Jupiter, but this was remedied through an ingenious suggestion by Mr. Plummer; and, secondly, because there was something peculiar in comparing wedge extinctions of points of light with objects of sensible area. Capt. Abney, however, pointed out to him a means of solving the difficulty by suggesting the use of little holes, wedging and calculating their capacity for transmitting light. This he did, and it resulted in proving that the wedge-extinctions were subject to a systematic error of ·83 mag. Applying this correction, the resulting albedoes came out almost in direct accordance with those obtained by Prof. Pickering with an entirely different instrument, which, to say the least, was interesting. Dr. Spitta then made a few remarks on the difficulty of making small holes, and closed his paper by reminding the Fellows that as the resulting albedoes of the satellites would be found to comply with the requirements of the experiments, it was more than probable that the peculiar phenomena presented by the satellites in transit were due to functional idiosyncrasies in the eye rather than to physical peculiarities of the Jovian system.

Mr. Plummer said the subject that Dr. Spitta has brought before the Society is especially interesting to me, since he has employed the wedge-photometer, an instrument with which I have had much to do, and which I believe capable of great accuracy. The series of observations by Dr. Spitta is the longest executed outside the Oxford Observatory, and I have much pleasure in noticing that he has by his great care reached a superior accuracy to ourselves.

Prof. Pritchard read a paper on "Further Researches on Stellar Parallax by the Photographic Method." He said: In my last communication to the Society, I gave the results of an investigation of the parallax of the two components of 61 Cygni, each being referred to four comparison stars independently. These eight independent results cohere in a very remarkable manner, and together furnish a mean value of the parallax identical with that derived from the determinations of Bessel and subsequent astronomers.

Encouraged by the hopefulness of this new method, I entered on the discussion of the parallax of μ Cassiopeiæ and of the Pole Star. The necessity, however, of improving the mechanism of the De La Rue equatoreal, now much worn by long and honourable service, greatly interrupted the continuity of the work. Aided by the continued generosity of the original donor (Dr. De La Rue) this instrument was ultimately restored to very effective order by Mr. Simms, and since its restoration the research has continued without avoidable interruption.

On each of fifty-three nights, four photographic plates were taken of μ Cassiopeiæ. The exposures varied from five to ten minutes. About three per cent. of these plates were found to be injured and unsuitable for the inquiry. This number of defective plates is so small that, in the work to be presently described, I have adopted the method of taking two impressions on the same plate, slightly moved in position, and in this way both labour and expense are economized. The details of all these researches will in due time be published by the University in a third fasciculus of their observatory proceedings. Awaiting this publication, I here give simply the results of the investigations.

Two suitable stars (here called A and B) were selected as comparison stars of approximately the eighth and tenth magnitude. The resulting parallaxes are as follows:—

From Star A $\pi = 0''{\cdot}0501 \pm 0''{\cdot}0270$
From Star B $\pi = 0\ {\cdot}0211 \pm 0\ {\cdot}0235$

If a correction to the adopted proper motion of μ be omitted, then the respective values are

From Star A $\pi = 0''{\cdot}0677$
From Star B $\pi = 0\ {\cdot}0429$.

These parallaxes are extremely small, and, taking into consideration the large proper motion of μ Cassiopeiæ, are interesting. Bessel in 1816 investigated the parallax of this star by means of differences of right ascension on seventy nights, but he arrived at a *negative* value of 0″·12. It is, however, both proper and interesting to remark that this research and its result apply to a time long anterior to the introduction of the heliometer in 1836. In 1856 Prof. Otto Struve obtained a parallax of this star by means of micrometrical comparisons amounting to 0″·342; a quantity well within the compass of Bessel's method in 1816.

On reviewing the laborious processes adopted for the parallaxes of the foregoing stars, it occurred to me that it would be a matter both of interest and importance to inquire what results would have been obtained had the measures been confined to a few nights only, when 61 Cygni and μ Cassiopeiæ were respectively at their greatest and least apparent distance from the comparison-stars selected. Accordingly, this method was applied first to 61 Cygni, where the nights of maximum and minimum distance were selected from the entire group of 89 nights. The result was a parallax of 0″·4089 as compared with 0″·4321 from the entire series.

Encouraged by this result, the number of nights selected was still further experimentally reduced to five nights in the case of μ Cassiopeiæ; and these gave, relatively to the two comparison-stars mentioned above, the respective parallaxes of 0″·055 and 0″·095, in place of 0″·050 and 0″·021. The probable errors, however, as was to be expected, were sensibly increased.

Bearing in mind the unavoidably approximate character of even the most elaborate investigations of stellar parallax, and especially when set side by side with the result obtained from this curtailed method, I have been induced to abandon the very laborious pro-

cesses applied to 61 Cygni, and hencefor
to five nights in each of four periods of
position of the parallactic ellipse. It is
the parallaxes of from ten to fifteen sta
mined within the year. I propose to
first instance, systematically to all thos
$1\frac{1}{2}$ and $2\frac{1}{2}$ which attain at Oxford a sui
it is already in course of application
γ and ϵ Cygni. Forming my expectati
the past, I am led to hope that the par
by this method will be obtained wheneve
thirtieth of a second of arc. For I fin
from four cases, that the probable erro
probable error of a "distance," does
second of arc; and inasmuch as the sq
the parallax derived from the solution
is $3''\cdot6$, the probable error of a par
thirtieth of a second.

Certain cosmical relations cannot b
from the parallaxes of numerous sta
classes of approximate parallax will b
what more accurate determinations in

I had hoped to have completed by th
of the Parallax of Polaris by the more
61 Cygni. The serious interruptions
alluded to necessitate the continuance
next. Meanwhile I may mention th
selected nights has given a parallax a
which, according to Mr. Maxwell H
($0''\cdot043$) of all the determinations mad

Capt. W. Noble then read a paper on "
of his Observatory." This paper was,
to young astronomers. When setting
mined his latitude and longitude to be 51
respectively, and these quantities he c
During that year a survey of the sout
a bench-mark was cut on one of his ga
a good opportunity of checking his pos
for the latitude and longitude of the b
values $51^\circ\ 0'\ 52''$ N. and $4'\ 25''$ E.
accurate until, from various causes, he
he again wrote to the Ordnance Surve
the following position:—latitude 50°
$4'\ 14''\cdot9$ E.; triangulating from which,
of his transit-pier to be situated in
longitude 17·11 secs. E.

Prof. Pritchard stated that he also
of his transit-circle, and obtained wh
accurate latitude and longitude. He

had made a mistake in his method of applying. Had he stated for what object he required the information, no doubt more trouble would have been bestowed on it.

Mr. Criswick then exhibited some photographs of several star-groups which he had taken at Greenwich. Some were taken on plane and others on curved plates with a Dallmeyer objective, belonging to one of the Transit-of-Venus photoheliographs, 4 inches aperture and 5 feet focal length, mounted on the telescope-tube of the Sheepshanks equatoreal, the equatoreal-telescope being used as a pointer. The photographs were taken for the purpose of determining the amount of distortion at different parts of the plate.

The Astronomer Royal. These photographs have an important bearing on the proposed photographic map of the heavens, as they indicate that it may be practicable to obtain an available field of 4° or even 5° in diameter on flat plates with a suitable object-glass. Wishing to test the question whether a larger available field could be obtained with curved plates than with plane, I arranged, in concert with Mr. Criswick, to have one of the Dallmeyer 4-inch object-glasses, of 60 inches focal length (corrected for photographic rays), mounted in a square wooden tube and attached to the tube of the Sheepshanks telescope; and with the combined instrument Mr. Criswick has taken these successful photographs, which testify to the great skill and patience he has shown in the instrumental manipulations. The form of the Dallmeyer object-glass is peculiar, the flint being outside. It is composed of a flint meniscus, convexo-concave (the curvature of the interior concave surface being nearly double that of the convex), and of a double convex crown, the last surface being nearly plane. On working out the radii for this form, required to correct the spherical and chromatic aberrations for photographic rays, I find that the theoretical curvatures agree sensibly with those arrived at practically by Dallmeyer.

Some photographs were also taken with the object-glass reversed, *i. e.* with the crown outside. These appear to be slightly inferior in extent of available field to those taken in the normal position with the flint outside. The curved plates, which have a radius of 22 inches, and are 6 in. × 6 in. square, were made by Messrs. Chance, and coated by Mr. Leo Atkinson, of Greenwich. The results with them are fairly satisfactory; but in view of the field which is available on the flat plates, I am doubtful whether the gain with curved plates would be sufficient to compensate for the difficulties attending their use for such a work as the photographic map.

I may add that Mr. Turner and I are engaged on measurements of the plates taken by Mr. Criswick (especially of the Pleiades in different parts of the field), with reference to distortion at different distances from the centre of the field and with different exposures.

Prof. Pritchard said that he was not surprised to hear that the

Astronomer Royal had arrived at the
meyer, for he knew that Dallmeyer wa
work out his curves theoretically.

Mr. Turner read a paper giving a
obtained with a personal-equation ma
vatory, Greenwich. He observed th
equation had for a long time exercised
and had been considered in several
Among these he might specially men
had arranged an instrument for m
subject, and had carried out a long
nomer Royal had recently devised a
respects superior to that of M. Wolf
that the transit-circle telescope was
vations, just as in star-observing. Th
an account of the first complete seri
instrument, the subject of investiga
personal equation with the change in
the star observed. M. Wolf's experi
conducted by himself, and thus did n
generalization as those at Greenwic
regular observers, who had been subje

The working principle of the instr
he proceeded to explain it with a few
He then referred to two diagrams whi
results obtained with the machine for
that, though the machine had taken s
working order, all concerned had been
accuracy and consistency of the res
remarked that his part in the inv
to collect and discuss the results of
selves had been kept carefully in ignor
ments, referring in this connection to
that a knowledge of such results had p
upon his own personal equation.

General Tennant. Some years ag
made as to the absolute determinatio
they naturally came to the same resul
the polar distance. I have always obj
vations, because they were taken with
the one actually in use. The system
It is now many years since I tried to
Indian Survey that the error of a Tra
one the error of bisection, and the oth
of time; and it is very important that
greatest near the pole, and the error o
the equator, and that makes a very ma
two or three errors of various sorts you
out the probable error, and this syste

the different effects. As a matter of fact, people do bisect a circular disk very differently.

The Astronomer Royal. Perhaps I may add that, besides these measures Mr. Turner has mentioned, there were also observations made, in which the star was moving half as fast again as an equatoreal star; so that Mr. Turner's tables are continued beyond the usual limits of observation. That seems to give greater certainty to the conclusions, I think. Another point is, that the probable error at the bottom of the diagram (N.P.D. 9°) is considerably less than the diameter of the dots, and about one quarter the diameter of the dots in the upper part, so that that will give a sort of idea of the degree of accuracy that can be obtained.

Capt. Noble. It is beautifully ingenious.

The Astronomer Royal. There is no special originality in this machine. Other personal-equation machines have been made; but the point I have had in view was to make the conditions of observations with the machine as nearly as possible those of the ordinary star-observations, and therefore the same object-glass is used, which has not been the case, I think, in other investigations. I think it is a matter of importance that the observer should be under precisely similar conditions of observation, as far as possible. I propose to continue the subject by investigating the personality in observing limbs, which I think is one of even greater importance than that of determining the personal equation of stars which can be found by other means.

Mr. Knobel. I suppose you had to bore a small hole to see the stars?

The Astronomer Royal. Yes; I found I could do it better myself than by getting anybody else. A very simple way of doing it, though requiring a little care, is to drill a hole nearly through the plate until a burr is raised, and then with a fine needle to work it in by hand from the other side until it is through. I think a hole of $\frac{1}{500}$th of an inch can easily be made. It is, however, one thing to make a hole and another to keep it, because dust gets in and there is a tendency for the hole to get bigger as you clean it from time to time.

Dr. Spitta. Was it really circular?

The Astronomer Royal. Yes; I examined it with a dynanometer. I found that a hole of $\frac{1}{500}$ inch was a practicable hole to make; but a hole of $\frac{1}{1000}$ inch would be much more difficult.

Dr. Spitta. I have one in my pocket now, measuring $\frac{19}{10000}$ inch. But the difficulty I found with any small holes made with a needle is that they were not circular.

The Astronomer Royal. I think with a little delicate manipulation you can make a hole circular—sensibly circular.

The following papers were also announced:—

W. H. S. Monck. "Oxford and Harvard Photometry compared."

A. Marth. "Ephemeris of the Satellite of Neptune, 1887–88."

Lord McLaren. "On the Images formed by Reflecting-Mirrors." (Second paper.)

J. E. Gore. "On the Orbit of *p* Eridani."

Sir R. S. Ball. Occultation of Regulus by the Moon, observed at Dunsink Observatory."

Rev. S. J. Johnson. "Occultation of Regulus."

W. T. Lynn. "Galileo Galilei and his Condemnation."

J. E. Plummer. "Observations of Comets made at the Orwell Park Observatory in the years 1886–87."

I. Roberts. "On Photographs of the Nebulæ 57 M Lyræ, 27 M Vulpeculæ, the Cluster 13 M Herculis, and of Stars in Cygnus."

Rev. S. J. Perry. "The Total Solar Eclipse of August 19, 1887."

A. M. W. Downing. "Note on the probable Errors of the Star-places of the Argentine General Catalogue for 1875 and the Cape Catalogue for 1880."

Prof. T. H. Safford. "On the Reduction of Star-places by Bohnenberger's Method."

A. Marth. "Ephemeris for Physical Observations of Jupiter, 1888."

Dr. R. Copeland. "The Total Solar Eclipse of August 19, 1887."

Thomas Bauchope was duly elected a Fellow of the Society.

The Meeting adjourned at 10 P.M.

Meeting of the Liverpool Astronomical Society.

THE second meeting of the Session was held in conjunction with the Literary and Philosophical Society, at the Royal Institution, on the 14th inst., Mr. James Birchall, President of the Literary and Philosophical Society, in the Chair. There was a very large attendance, and fifty-four members were proposed and elected.

Mr. Sadler read a paper on "Photographing the Stars." He mentioned that the first photographic pictures of the Sun and Moon were obtained nearly fifty years ago, but that it was not till 1845 that Mr. W. C. Bond of the Harvard Observatory, in conjunction with Mr. Whipple of Boston, succeeded in taking photographs of the stars Vega and Castor. These were daguerrotypes, but with the discovery of the collodion process in 1851 by Mr. Archer, photography entered on a new phase of existence, and astronomers were not slow in availing themselves of the improvements arising from increased facility in the manipulation of, and diminished length of time in the exposure of, the sensitive plate. In the course of his paper Mr. Sadler traced the various advances in the art of stellar photography, from this date until the present day, and exhibited a large number of stellar photographs by Mr. Common, MM. Henry, and others, among them being some of the star Capella, taken a short time ago. It was stated that the rays of light, which, acting on the sensitive film, impressed the image of this distant Sun on the photograph in question, started on their voyage in the year of the battle of Waterloo.

In a paper on the "Causes of Variation in the Light of Stars," Mr. W. H. S. Monck, M.A., F.R.A.S., remarked that variable stars had been divided into classes by more than one writer on the subject, and that the object of the present paper was to assign the most probable causes of variation in the case of each class. The transit of a dark satellite over the face of the principal star appeared to be the most probable cause of the periodical variation of stars of what is known as the Algol type. The satellite might be dark, or a nebulous body, or a flight of meteors. Variable stars belonging to the second class are also periodical, but differ in many respects from those of the Algol type. The intensity of the light constantly varies, and the period is usually much longer than in the case of stars of the first class, almost all the stars of the second class being red. An exaggeration of the phenomenon of solar spots, with shorter intervals for their recurrence, seems the most feasible explanation in the case of stars of this class. A third class of variable stars consists of those which are irregularly variable, including those known as New or Temporary stars. Either collision with one or more solid bodies or motion through a resisting medium, such as a gaseous nebula, would explain with some plausibility the phenomena of variation in the light of stars of this class. To these three causes Mr. Monck would ascribe variation in the light of stars. He would exclude rotation on an axis for two reasons—first, because he knew of no cause calculated to make one side of a rotating star darker than the other; and secondly, because rotation on an axis will not explain the facts without attributing an improbable figure to the rotating body.

In "Notes on Venus" Mr. Denning said that inasmuch as Venus is by far the most splendid of all the planets as a naked-eye object, one would expect that instrumental power would greatly enhance the picture, and reveal more striking appearances than can be seen in less conspicuous planets. But that is a delusive hope; the lustre of Venus is so great that her disk is rarely defined with satisfactory clearness, while there are no dark spots of bold outline, as in the case of Mars, to diversify her surface; or system of rings or belts, as in the cases of Jupiter and Saturn, or system of revolving satellites, such as accompany each one of the superior planets, to render a telescopic view a very attractive one. Mr. Denning observed that after subjecting Venus to a most careful examination during the last twenty years, he had not been able to detect the slightest traces of the lofty mountain seen, or imagined, by Schröter; while though he could very readily discern spots with 2, 3, and 4½ inch telescopes, with his 10 inch reflector.

in which the image was immensely improved and expanded, there remained only the very feeble grey appearances which constitute the only really observable markings on her surface.

In a paper entitled "The Positions and Colours of Binary Stars," Mr. J. E. Gore, M.R.I.A., F.R.A.S., stated that in eight cases the plane of the star was at right angles, or nearly so, to the Milky Way; while that of the 96 poles of 48 computed orbits, 60 lie between 150° and 300° R.A., showing perhaps some tendency to a plane, of which the pole is in R.A. 10^h to 20^h, and not very far from the Equator, chiefly to the north of it. The following interesting relations between the magnitudes and colours of the components of binary stars is not new, but as it is not generally known it may prove of interest. Firstly, when the magnitudes of the components of a binary star are equal, or approaching equality, the colours are generally the same or similar; secondly, when the magnitudes of the components differ considerably, there is also a considerable difference in colours.

The following papers were also read:—"Notes on Meteor Observations," by W. F. Denning, F.R.A.S.; "The Quadrantids in 1888," by T. W. Backhouse, F.R.A.S.; "Report from Coloured Star Section," by W. F. Franks, F.R.A.S.; "The Moon surveyed in Common Telescopes," by T. E. Elger, F.R.A.S.; Planetary Delineation in very small Instruments," by Rev. S. J. Johnson, M.A., F.R.A.S.

La Société Astronomique de France.

It has long been a matter of surprise to astronomers that a country which has done and is still doing so much for our science, should possess as yet no society expressly devoted to promoting its interests. This anomaly has at length been removed by the formation of a society bearing the above title, a society founded, in the words of its statutes, "with the design of uniting together those who are engaged practically or theoretically in the pursuit of Astronomy, or who are interested in the development of this Science, and in the extension of its influence for the enlightenment of the intellect. It efforts will be directed to the advancement and popularization of this Science, as well as to the assistance of all those who wish to take up astronomical studies." The seat of the Society is to be in Paris, for the time being in the Rue Cassini, near the Observatory, and the meetings will be held once a month, except during the months of July, August, and September. The general organization of the Society will be very similar to that of the Royal and Liverpool Astronomical Societies; M. C. Flammarion who has won so wide an influence in France, and who has done so much to develop there a general interest in astronomy by his numerous popular works on various branches of the science, and by his review 'L'Astronomie,' being most appropriately the first President. The other officers and members of Council are:—Vice-Presidents: Paul and Prosper Henry, Gen. Parmentier, and E. L. Trouvelot. Secretary-Treasurer: P. Gérigny. Vice-Secretary: A. Gunziger. Council: E. Bertaux, E. Blot, E. Daguin, C. Detaille, Léon Fenet, C. M. Gaudibert, Jeanrenault, L. Gully, Col. Laussedat, Dr. Lescarbault, A. Schmoll, G. Secretan, Comte de Touchimbert, and Ch. Trépied.

The first Meeting of the Society was held on Oct. 12, the President, M. Flammarion, in the chair.

M. Trouvelot read a paper on "A Double Shadow of Jupiter's First Satellite." The observation was made by M. Trouvelot with the 6¼-inch equatoreal of his private observatory at Cambridge (U.S.) on April 24th, 1877, at $15^h\ 25^m$ Cambridge mean time. The shadow of the first satellite had entered Jupiter's disk 39 minutes before, at $14^h\ 58^m\ 42^s$, and had not quite described a quarter of its course on the planet's disk. The shadow was black and sensibly elliptical in form, and nearly touched by its most northern point the northern edge of the rose-coloured equatoreal zone. It was preceded on its western side by a fairly dark spot of exactly the same shape and size, which was separated from the shadow by an interval not exceeding one-third of the equatoreal diameter of the latter. This singular spot was not exactly on the same horizontal line with the shadow of Jupiter's first satellite, but was situated a little further towards the south, by about one-third of the vertical diameter of the shadow. At $16^h\ 6^m$ the shadow and the spot arrived at the central meridian of Jupiter; nothing in their appearance was changed. M. Trouvelot observed the phenomenon for the last time at $16^h\ 45^m$. At that moment the shadow had described three quarters of its course on the Jovian disk, and had been always preceded by its companion, the relative distance of the two objects not having varied during the observation. This dark spot was not the satellite itself, for that object was seen to enter on the disk at $16^h\ 4^m$, and it moved much too rapidly to be a marking of the planet itself. The most natural way of explaining this phenomenon was by supposing that the second spot was the continuation of the primary shadow formed on a layer of Jupiter's surface sufficiently thin and transparent to allow it to filter through its interstices, to pass then through a transparent medium, and to fall finally on a second deeper surface, perhaps that of the solid globe of the planet. In concluding, M. Trouvelot reminded the society that several observers had seen Jupiter's satellites after their occultation, just as if the limb of the planet had been transparent.

M. Ch. Moussette exhibited a photograph of a solar spot, and some very fine photographs of the solar spectrum on a large scale.

The President announced that the Calendar Reform prize, consisting in money and medals to the value of 5000 francs, would be delivered at the next meeting.

*The Rejection of Discordant Observations**.

The question, what shall be done with observations that present large discordances from a mean value, is one that will continue to perplex investigators for a long time. The founders of the method of least squares have called attention to the fact that the law of error which is derived from the assumption of the arithmetical mean as the most probable value is not rigorously correct. This is expressly stated by Gauss in his 'Theoria Motus'; and for a finite number of observations, a condition which always holds in practice, similar statements have been made by Laplace and Poisson, to whom we are indebted for the most general investigations of the law of error. The rule of the arithmetical mean is justified on the ground that it corresponds to common sense and universal practice. Criticisms and improvements of the method of least squares, therefore, will always be in order, whether they pertain to modifications in the law of error itself, or simply propose to change some of the constants into more general functions to be determined to suit special cases. Let us look at some of the results obtained by means of the methods proposed for dealing with this difficult question.

Peirce's Criterion.

This criterion was given by Professor Benjamin Peirce in 'Gould's Astronomical Journal,' vol. ii. p. 161. Though warmly recommended by several eminent American astronomers, this criterion has never come into general use, but it has been employed for a long time by Mr. C. A. Schott, chief of the computing division of the United States Coast and Geodetic Survey. Such a practical recommendation is important, even though Mr. Schott qualifies it by the warning that care must be taken in its use, since sometimes this criterion "cuts too deep." Professor Peirce applied his criterion to two examples. The first is that of thirty observations of the semidiameter of Venus made with the mural circle of the Naval Observatory in 1846. After a reduction of these observations Professor Peirce finds the probable error of a single determination to be ±0″·28. His criterion rejects no observation. The second example is that of fifteen observations of the same semidiameter made with the meridian circle of the Naval Observatory in the same year. In this case the probable error of a single determination is ±0″·39; and two observations giving the residuals +1″·01 and −1″·40 are rejected by the criterion. After this rejection the probable error of a single determination is ±0″·21. This diminution of the probable error is a suspicious circumstance. It is well known that observations with the mural circle were more accurate than those made with the old meridian circle; and the values of the probable errors found before the criterion was applied correspond very well to the relative accuracy given by a large number of observations. It is perhaps from such consideration as this, and from noticing how an apparent accuracy may be given to inferior work, that this criterion has been prevented from coming into general use. Since this second example is often referred to by writers on this subject, it may be well to state, though it does not affect the argument, that the records show that not one of the fifteen observations was made by Lieutenant Herndon.

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* Reprinted from the 'Sidereal Messenger,' Nov. 1887.

STONE'S CRITERION.

Mr. E. J. Stone, the present Radcliffe observer, does not accept the criterion of Professor Peirce, and in the 'Monthly Notices' of the Royal Astronomical Society, vol. xxviii. p. 165, he gives a rule of his own. If a given observer makes one careless observation in 500, Mr. Stone finds that the limit of rejection is about five times the probable error of an observation. Thus, if the probable error is $\pm 0''\cdot 48$, and an observation gives the residual $2''\cdot 5$, this observation should be rejected. This is a very simple criterion, and can be applied easily. We infer from the method of least squares that in a thousand observations there will be but a single error greater than five times the probable error. The application of Mr. Stone's criterion therefore could not do much harm, and yet I think astronomers would hesitate in applying it. The probable error $\pm 0''\cdot 48$ is about that of an observation with the common meridian circle, and, unfortunately, residuals as great as $2''\cdot 5$ are still apt to occur in this kind of work.

DE MORGAN'S METHOD.

Professor Augustus De Morgan proposed a method of weighting observations by means of approximate solutions until the assumed and deduced weights agree. Not having seen De Morgan's exposition of his own method, I cannot speak of it with accuracy. It has been referred to as a method of meeting the difficulty of discordant observations by diminishing their weight. The weight depends on the probable error, which should be found from the whole series of observations. If the discordant observations are so managed as to be given arbitrarily a very small weight, this process would become equivalent to a rejection. The criteria of Peirce and Stone seem to meet the question more fairly.

Besides these criteria, two other methods have been proposed for use in the discussion of observations. The first is a proposal to change the law of error which is adopted in the method of least squares for one in which the first power of the error enters. In his earlier investigations Laplace adopted a law of this kind, but he soon discarded it for the one now used. It is true that the strict method of least squares sometimes leads to great labour of computation, and it may be well in some cases to shorten the work by grouping the observations. This can be done without changing the law of error. Again, it may be sufficient for some observations to reduce the equations of condition by the old method of making the sign of similar terms the same, then adding all the equations, and thus deducing a set of normal equations. This will generally give a good result; but if the observations are accurate, it is better to spend a little more labour on them.

Another method has been proposed for the treatment of discordant observations in which the law of error assumed in the method of least squares is retained, but the measure of precision is made a function of several unknown quantities, which are to be determined from the residuals found from a preliminary comparison. There can be no doubt that in a given series of observations the measure of precision is not a constant, as is commonly assumed; and it must certainly be subject to small fluctuations dependent on the condition of the observer and his instrument. It might vary with the daily allowance of food and stimulant provided for the observer. Now it seems probable that if we split an assumed constant into several parts, and attach various meanings to them, we shall be able to represent the observations more accurately. In the case of the fifteen observations of the semidiameter of Venus, observed in 1846, such a process would permit us to represent the residuals very well. But into how many parts shall we divide the measure of precision; two, five, or fifteen? We might assume a periodical series and satisfy the residuals exactly; but after all the labour, one cannot avoid the suspicion that this procedure is nothing more than an attempt to conceal ignorance under mathematical forms.

The question recurs whether there is any advantage in the discussion of observations by means of these rules over the judgment of an experienced investigator. I think the reply must be in the negative. For most cases of discordance that occur in practical astronomy the judgment of an experienced astronomer will be better than any arbitrary rule. Take, for example, the observations of a solar eclipse, or the transit of one of the interior planets. For several reasons such observations are liable to large errors. The heat of the Sun and its effect on the eye and instrument in confusing the images, and the slow motion of the planet, make a little maladjustment of the instrument capable of producing errors of 20 or 30 seconds of time. The usual result is that many observations are made by inexperienced observers, and sometimes by those who have no good means of knowing their local time. Now an astronomer of experience will extract a better result from these observations than can be found by any set of fixed rules. His methods may seem arbitrary, but he is the last and best resort. Of course, in cases where each observer has made a considerable number of observations, the probable errors of the different series will furnish the combination weights.

There is one peculiarity of observations which may seem to partake of a discordant nature that should not be lost sight of. This is what Mr. M. H. Doolittle, of the Coast Survey Office, calls their *instructive* character. Observations should not be rejected until they have been carefully scanned, since they may contain important information. Several inequalities in the motions of the planets and the Moon have been discovered by apparently discordant observations; and although satisfied for a time by empirical formulæ, they have frequently led to theoretical explanation. We sometimes see careful observations in astronomy that evidently contain systematic errors. These errors are commonly included under the vague terms of "flexure" and "refraction"; and generally they may be taken as good evidence that the astronomer has not become master of his instrument. Such results should spur him on to further investigation.

The method of least squares is a beautiful application of the theory of probabilities, and it is the best method of treating observations that has been devised. It is an instrument, and observers should become familiar with it and learn to apply it correctly. It was never designed, as Delambre sarcastically remarks, to make good observations out of poor ones, but it gives the best result from the given data.

U. S. Naval Observatory,
Washington, D. C.
1887, Oct. 6.

Asaph Hall.

Meteor Notes.

Between October 11 and 24 I observed 459 meteors during 46¾ hours of observation, and about 21 radiant-points were determined. The shower of Orionids was visible during the whole period named, and I recorded 90 of its meteors. A special effort was made to discover whether the centre of radiation retains a fixed position or, like the August Perseids, becomes rapidly displaced relatively to the neighbouring stars. From seven well-defined radiants of the Orionids, observed on different nights, it was found that no change whatever occurs in the position of the radiant. There are small variations apparent amongst the results, but they are not in the same direction and are simply attributable to errors of observation. The display of Orionids endures during the three weeks embraced by the period from October 9 to 29 inclusive, and the meteors emanate from a stationary point at 91° + 15°.

Another rich shower has recently been visible, viz. the Arietids, with a radiant at 40° + 20°, from which I saw 45 meteors. I called attention to this stream in the 'Monthly Notices' for Nov. 1880, pp. 24, 25, as one furnishing a considerable number of fireballs at the epoch of the Orionids. Showers are very abundant in this region during the summer and autumnal months.

In addition to the Orionids and Arietids, the best showers recently seen were:—

No.	Date, 1887.	Radiant.	Notes and Comparisons.
1...	Oct. 14–15	25° $+44^\circ$	Slow; faint. Heis, 24° $+42^\circ$, Oct. 17–Nov.
2...	Oct. 17–23	47 +44	Swift. Corder, 45° $+47^\circ$, Oct.–Nov.
3...	Oct. 14–21	54 +71	Swift. D., 53° $+71^\circ$, Oct. 5–7, 1885.
4...	Oct. 14–21	105 +22	Very swift; streaks. D., 106° $+23^\circ$, Oct. 15, 1879.
5...	Oct. 20–21	125 +43	Swift; streaks. Near 31 Lyncis.
6...	Oct. 14–23	135 +68	Swift. D., 133° $+68^\circ$, Oct. 2–19, 1877.
7...	Oct. 12–20	312 +77	Swift. D., 310° $+77^\circ$, Oct. 2–20, 1877.

Mr. David Booth, at Leeds, observed more than 60 meteors during a watch of 5 hours on Oct. 20, and found two very definite radiants, namely at $90^\circ + 16^\circ$ and $88^\circ + 20\frac{1}{2}^\circ$. There was also a radiant at $99^\circ + 22^\circ$, which is probably the same as the shower at $105^\circ + 22^\circ$, seen at Bristol.

Several fine meteors were recorded in October. The brightest seen at Bristol belonged to the Orionids; it appeared at $11^h\ 58^m$ on Oct. 17, and traversed an arc of 19° from $72^\circ + 11^\circ$ to $53^\circ + 5\frac{1}{2}^\circ$, leaving a streak for several seconds. This meteor was as bright as Venus.

On October 29, just before 6 A.M., a meteor of extraordinary brilliancy was seen at Ellel, near Lancaster. The observer was walking in a southerly direction, when he suddenly saw the ground lit up about him as if by a flash of lightning. Looking upwards, he noticed that the N.W. sky was involved in a blaze of light, occasioned by a large fiery-red ball of extreme brightness, which passed across the sky to the N.E, followed by a train of bright sparks like stars, and disappeared. The phenomenon endured altogether about a minute, so that the meteor moved slowly, and enabled it to be steadily observed. The nucleus had a perceptible diameter, and though it did not look so large as the Moon, it was considerably more brilliant and fiery.

On November 4, about $6^h\ 40^m$, Mr. G. T. Davis, at Theale, near Reading, observed a large meteor, =Venus, falling from $281\frac{1}{2}^\circ + 24^\circ$ to $282\frac{1}{4}^\circ + 11^\circ$. Duration about 2 sec.; motion exceedingly slow. On Nov. 6, about $7^h\ 53^m$, a meteor, =Jupiter, was seen by Mr. Davis passing from $296^\circ + 11^\circ$ to $287\frac{1}{2}^\circ + 8\frac{1}{2}^\circ$. It left a slight trail.

On Nov. 13, at $9^h\ 58^m$, a very brilliant meteor was observed at Freshford, near Bradford-on-Avon. Although the atmosphere was cloudy at the time it illuminated the surrounding country with its very bright light. It first appeared overhead and passed out of sight in the S.E. On Nov. 15, 9^h, a fireball was seen in Wales.

Several other large meteors have been recently registered by Mr. Booth at Leeds and the writer at Bristol, but it is unnecessary to give details.

The nights of November 11, 12, and 13 were overcast at many places, and observations were prevented; but the 14th was clear, and at Bristol 29 meteors were recorded between $14^h\ 30^m$ and $17^h\ 30^m$. Of these, about 7 were Leonids from a radiant at 150°

+22°. One of these was nearly stationary close to its radiant, the observed path being from 151° +20° to 151½° +18½°. In 1885, Nov. 14–17, I found the Leonid radiant also at 150° +22° (11 meteors), in 1879, Nov. 13, at 148° +23° (18 meteors), and on Nov. 10–13, 1877, at 148° +24° (5 meteors).

Mr. Booth, at Leeds, watched the sky between $11^h\ 30^m$ and $14^h\ 55^m$ on Nov. 14, and registered 23 meteors; 6 of these indicated the Leonid radiant at 155° +25°, and there were 5 Taurids from 58° +21°. W. F. DENNING.

Bristol, 1887, Nov. 20.

Selenographical Notes.

RILLS WEST OF MERSENIUS.—In 'Sirius' for July 1879 is a reproduction of a remarkable drawing of Mersenius and its surroundings, made by Gruithuisen at 4 A.M. on 24th August, 1821, in which he shows prominently two parallel clefts, in a situation where, I believe, no features of the kind have been subsequently recorded. On the western flank of the ring-plain there is a lofty rocky ridge connecting the large depression adjoining Mersenius *c* with the little ring-plain *d*. The more northerly of Gruithuisen's rills is represented as originating at the junction of the rocky ridge with the western wall of the depression, and as following a slightly curved course, convex to the south, crossing the great Gassendi rill, β (Neison, Map XV.), nearly at right angles, and then trending apparently towards the mountainous regions forming the eastern border of the Mare Humorum, between Gassendi and Mersenius *d*. The other cleft commences a little west of Mersenius *c*, and also crossing the Gassendi cleft β, runs parallel to the first at a distance of 15 or 20 miles south of it. Neither in Schmidt's excellent delineation of this district in his 'Rillen,' nor in his large Map, or in those of Beer and Mädler, or Neison, is there the slightest indication of these two large clefts, nor are there apparently any crater-rows or ridges lying in their direction. The five or more rills which border the Mare Humorum in this neighbourhood all trend nearly southwards, while the objects observed by Gruithuisen strike across them from E.S.E. to W.N.W.

A slur has often been cast upon Gruithuisen's lunar observations on the ground that he was inclined to set down more than he actually saw; and, especially as regards the rills, it has been considered that a lively imagination frequently led him astray. The more careful and systematic study of these delicate features during the past twenty years has, however, sufficed to show that his records are by no means to be depreciated. Many rills which he detected, whose existence could not be verified by other observers, have subsequently been re-discovered—notably some pertaining to the Hyginus and Triesnecker systems; hence, notwithstanding that those he draws west of Mersenius have not been set down by other selenographers, it would be premature to deny their existence, especially as, though the region has been frequently scrutinized under morning illumination, it is so inconveniently situated for observation at sunset that we possess scarcely a drawing made under these conditions. Hence it is impossible to say with certainty that Gruithuisen's rills are not visible at this stage if carefully searched for. At any rate it is strange that an observer who devoted so much of his attention to the detection of clefts, and whose observations, once questioned, have in recent years been amply confirmed in so many instances, should represent, in a carefully executed drawing, two coarse clefts on a site where they did not exist. I may add that when Gruithuisen's drawing was made, the E. long of the evening terminator was about 55°.

Plinius, Dawes, and the Clefts on the North-east.—A favourable opportunity was afforded between 10^h and 12^h on September 7th for observing these formations at sunset, the bright little ring-plain Dawes being exactly on the terminator and the eastern half of the curious light-coloured area on which it stands being admirably placed for examination. It was seen to be bounded on the east by a low ridge and to be covered with a number of small hillocks. The ridge which extends for some distance round Dawes, and whose curvature is roughly concentric with its border, suddenly terminates where it abuts on the most northerly of the three clefts which radiate from the highlands near the Prom. Acherusia. It is noteworthy that this cleft, which originates north, not south as shown by Neison, of the promontory, coincides for the greater part of its length with that sudden well-marked and inexplicable change of tint on the south-western side of the Mare Serenitatis so obvious to every observer and in all good photographs. A branch from the ridge just mentioned also terminates abruptly at this cleft, and other features in the vicinity seem to have been modified by its presence. On the other hand, the southern end of the great serpentine ridge which crosses the western quarter of the Mare does not appear to be affected beyond being traversed by the cleft. I think no one can contemplate this region under the conditions which obtained on September 7th without being impressed with the idea that this cleft occupies the site of a vast "fault" extending along the whole of the south-western side of the Mare, which was formed subsequently to the ridges referred to east of Dawes, but which is probably of older date than the serpentine ridge.

On this evening two minute craterlets were seen on the southern wall of Plinius, one of which is shown by Schmidt. The coarsest of the three rills (δ, Neison, Map II.) was traced from its origin among the mountains south-east of the Prom. Acherusia, through the ridge east of Dawes, then, as a very fine black line, nearly up to the northern side of the ring-plain. Its many local variations in width, especially near the eastern end of it, were very conspicuous. An object which seems to be a short cross rill was traced from a crater-like widening in δ, nearly due north of the centre of Plinius, to the rill θ. It was also seen soon after lunar sunrise at $5^h\ 30^m$ on 21st January, 1885.

Kempston, Beds, 1887, Nov. 19. THOS. GWYN ELGER.

The Bibliography of Astronomy *.

FIVE years ago we had the pleasure of calling the attention of our readers to the appearance of the first of the three parts of this magnificent work, and we attempted to express our high sense of its usefulness and of the marvellous industry and research which it showed. We have now to welcome the publication of the earliest section of the second part, the remaining sections of which are already completed in manuscript, and may be expected to be in the hands of astronomers before long, as they are even now being passed through the press. Two-thirds of the great enterprise may therefore be considered as being now practically accomplished; that its authors may have the health and strength to bring the whole to a successful conclusion will be the fervent wish of every lover of science.

The volume which appeared in 1882, was the first in order of date, though the second in numeration, for MM. Houzeau and Lancaster felt that the need for it was more pressing than for either of the two others, since it dealt with Memoirs, that is scattered papers appearing in magazines or journals or contributed to scientific societies. The present volume deals, on the other hand, with complete Works separately published, whilst the third is to be devoted to Observations and Reports of Observations.

The volume on the Memoirs met, as its merits deserved, with a most favourable reception; and indeed it is scarcely possible to speak too highly of the courage which had planned so great an undertaking, the skill with which it had been arranged, and the industry, patience, and completeness with which it had been carried out. But the admiration excited by the earlier volume will certainly not be lessened by the portion of the present which has as yet appeared, and it will be acknowledged that MM. Houzeau and Lancaster have spent the five years since the publication of Volume II. to very good effect.

The present volume which, as mentioned above, treats of complete Works, will appear in three parts and be arranged in eleven sections, this first part including the first two sections, viz.,

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* Bibliographie Générale de l'Astronomie. Par J. C. Houzeau, Ancien Directeur de l'Observatoire Royal de Bruxelles, et A. Lancaster, Bibliothécaire de cet Etablissement. Tome Premier. Ouvrages Imprimés et Manuscrits. Première Partie. Bruxelles, F. Hayez. Juin 1887. 858 pp.

Historical Works and Astrology, besides an historical introduction occupying 325 pp. The sections to follow are Biographies and Correspondence, Didactic Works, Spherical Astronomy, Theoretical Astronomy, Celestial Mechanics, Astronomical Physics, Practical Astronomy, Descriptive Astronomy, and Systems.

The historical introduction from the pen of M. Houzeau of itself deserves an extended notice, but we must be content to say that he sketches in bold and vivid outline the evolution of the science from the earliest times to the present day, the recent discoveries in Egypt and Assyria being especially drawn upon in illustration of the earlier stages through which it passed. The personification of the stars led to their being worshipped, their worship led to the idea of their individual influence on the fortunes of men, and this again induced more careful study of their apparent movements. Astrolatry thus was the parent of astrology; astrology of astronomy. Very interesting are the author's remarks on the tenacity of old beliefs and the curious traces still remaining of modes of thought long disowned. The science in its earliest form dates back, M. Houzeau considers, to the age of stone, and in its empirical stage to the age of bronze; it is practically the work of the last three centuries, and of these alone, which has given us those mighty conceptions of the universe, the grandeur of its dimensions and of its laws, which are ours to day. A progress so rapid, achievements so mighty, whilst men are still much hampered by the remnants of old superstitions and errors, lead M. Houzeau to anticipate still greater triumphs in the future. Astronomy has, in some sort, opened the way to the objective sciences; "she stands at the head of the column, her explorations have carried afar the limits of her domain. What other field, then, should be more likely to furnish in the time to come results more important than those of the past, and greater still?"

In the Bibliography itself, the method adopted is to print the name of the author in bold type at the head of the column, and then follow the titles of his various works. Under each work the date, place, and size of each successive edition is given; then follow translations with their editions. A brief summary of the subject and contents of the book is then given in the case of the more important, and lastly references are given to works or reviews in which the book in question has been summarized or reviewed. It will be seen at once that the mere number of the books indexed, though this amounts to nearly 6000, viz. 3596 Historical Works, and 2319 Astrological, affords but a very small indication of the amount of labour expended or of information conveyed. In truth we have here presented to us a complete chart of the history of the various books referred to; thus the great poems of Aratus, the "Phainomena kai diosêmeia," occupy four columns with their successive editions and translations; the paraphrases of Cicero, Germanicus, and Avienus not being included here, as they are indexed under their several authors. And not only are printed books thus fully catalogued, works in manuscript, particularly those of the Arabs and of the Renaissance era, are treated with great care, and the libraries where they are preserved are indicated. No such inventory of our wealth in astronomical manuscript has been ever prepared before. Works, too, relating to the astronomy of ancient Egypt, Assyria, India, and China are also given in a very complete manner. A special chapter is devoted to works on the Astrolabe, whilst the section of Astrology is almost a new undertaking, the great majority of works on that subject being very little known.

It is impossible to conclude our notice of MM. Houzeau and Lancaster's work without congratulating them on having brought it so far towards its conclusion, and giving expression to the sense of obligation which this most valuable undertaking will impress on all astronomers. The authors cannot hope for popular reputation and applause; the magnitude and value of their labours will be quite unappreciated by the multitude; it is specially incumbent therefore upon their fellow labourers in science, for whose service alone they have wrought, to give their scientific devotion and patient industry the most hearty recognition in their power.

E. W. Maunder.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Length of the Saros.

Gentlemen,—

On p. 392 of the 'Observatory' for the current month, I find Prof. Zenger saying: "Prof. Newcomb has kindly sent me his celebrated work on Eclipses, in which he gives the value of the lunar cycle, the Saros, as $6585^{d}\cdot3122$." Now on p. 31 of Newcomb's own 'Popular Astronomy' (ed. 1878) we read "The exact time required for 223 lunations is 6585·3212 days"; and as one of these periods is certainly wrong, it would be interesting to know which.

Faithfully yours,

William Noble.

Forest Lodge, Maresfield, Uckfield,
1887, Nov. 5.

The Variable Star Algol.

Gentlemen,—

Mr. Monck's communication on the above subject ('Observatory,' No. 128, p. 357) appears to call for a reply, though his criticism of my letter relates to a point of but slight importance.

The statement that I have mistaken "either the suggestion of Prof. Pickering or the object of the Greenwich observations" may be disposed of in a very few words. On the assumption that Goodricke's hypothesis is the true one, we have every reason to believe that the orbital motion of Algol will be very rapid. Hence, with the aid of the spectroscope, we may not only test the truth of this hypothesis, but we may, in case the existence of a satellite is established, also ascertain (approximately) the velocity with which Algol revolves in its orbit. This view of the matter appears to have been held by Prof. Pickering, as well as by myself *. It will therefore be evident that Mr. Monck's inference, as cited above, is quite unwarranted.

As regards the relative dimensions of Algol and its satellite, I am unable to see that Mr. Monck's arguments have any special bearing upon the points discussed in my letter. It is very possible that both Algol and its satellite may be surrounded by absorbing atmospheres; but, granting this, we may still conclude that the satellite is relatively a large body. There can be little doubt, moreover, that the *density* of the companion is greater than that of its primary, so that the *masses* of the two bodies may be nearly equal.

I will now venture to criticise, very briefly, the suggestion offered by Mr. Monck in the concluding paragraph of his letter. Granting that the motion of the Algol system in the line of sight has varied in past years, it is undoubtedly true that corresponding changes in the star's apparent period must have occurred. The idea is an ingenious one, but Mr. Monck has not suggested any *cause* for the acceleration of motion which he assumes to have taken place. It is not easy to see how this difficulty is to be surmounted; but unless a satisfactory explanation can be found, Mr. Monck's view will scarcely be accepted as probable.

Apart from changes of a periodic or irregular character, there is reason to believe that a very gradual *lengthening* of Algol's period has taken place through the agency of *tidal friction.* This very interesting subject has not, I believe, attracted attention hitherto. It will be readily seen, however, that Mr. G. H. Darwin's celebrated theory of tidal evolution is peculiarly applicable to the system of Algol. It thus appears highly probable that (as in the case of the Earth and Moon) the components of Algol originally revolved almost in contact with one another, and that the satellite has slowly receded from its bright primary through the influence of tidal friction.

It would be easy to dilate upon this interesting theme; but any further remarks may with advantage be postponed until the spectroscope shall have yielded its final verdict on the question—Has Algol a satellite?

Yours truly,
J. M. Barr.

St. Catharine's, Ont., Canada,
Oct. 26, 1887.

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* See the 'Observatory,' No. 48, p. 121. I should add, however, that Prof. Pickering's *alternative* hypothesis (viz. that the eclipsing body consists of a cloud of meteorites) is, to my mind, wholly untenable.

The Variable Star Algol.

Gentlemen,—

I have to thank you for referring me to Prof. Pickering's photometric measurements of this star. I had not an opportunity of seeing them until very recently. I find that they confirm the views expressed in my letter. The change in the light of the star is very little more than one magnitude. Supposing the surface of Algol to be of uniform brilliancy, and the density of the principal star and satellite to be the same, the mass of the satellite is a little less than one-half that of the principal star—a figure agreeing well with that of the satellite of Sirius. But, for the reasons stated in my last letter, the mass of the satellite may be less than this. The above result would lead to considerable changes in the figures given by Mr. Maxwell Hall in No. 111 of the 'Observatory.

Truly yours,

Dublin, Nov. 3, 1887. W. H. S. Monck.

The Periods of the Planets and Satellites.

Gentlemen,—

I need not say that I would be much gratified if Prof. Zenger succeeded in pointing out any physical significance in the numerical relations between the periods of the planets respecting which I wrote to you some time ago; I think, however, that he has not succeeded in doing so.

You are of course correct in remarking that if we take into consideration both positive and negative differences no number can differ from a multiple of $\frac{T}{2}$ by more than $\frac{T}{4}$, and that the mean difference apart from any law will be $\frac{T}{8}$. To indicate a law the mean difference should be considerably less than $\frac{T}{8}$.

But, independently of this, the exact period of the Sun's rotation is liable to considerable uncertainty. The figure assumed by Prof. Zenger, 25·19 days, is less than that generally adopted. Considering this uncertainty, what reliance can be placed on the residuals when the number of semi-rotations to be deducted varies from 344 to 4779? The exterior planets should therefore be excluded from the computation altogether, and as regards Neptune the uncertainty as regards its period affords an additional reason for the exclusion. We are thus reduced to four planets. In two of these the computed difference is small; in the third it is below the mean, while in the fourth it is nearly at the maximum. From such premises I think no conclusion can be drawn. However, Prof. Zenger's law, if true at all, applies no doubt to the asteroids as well as to the planets proper. The periods of at least 250 of these are known. If Prof. Zenger will make the requisite computations with regard to these asteroids they will go some distance towards either confirming or refuting his theory.

With respect to the satellites, however, I think the facts are decidedly opposed to the theory of Prof. Zenger. The satellites of Uranus and Neptune should, I think, be excluded, owing to the uncertainty of the rotation-period of these planets. Prof. Zenger omits the satellites of Mars; they not only disagree with his theory, but the inner satellite presents a peculiar difficulty, viz. that its period is considerably less than $\frac{T}{2}$, of which it ought (according to Prof. Zenger) to be a multiple. Omitting the satellites of Uranus and Neptune, we have to consider one of the Earth, two of Mars, four of Jupiter, and eight of Saturn, in all fifteen. In ten of these fifteen instances the differences exceed the mean, or $\frac{T}{8}$, and the average of the whole is also in excess of the mean. There would therefore appear to be a tendency in the periods of the satellites to avoid multiples of $\frac{T}{2}$. This fact is the more remarkable on account of the known numerical relations between the periods of the satellites *inter se.*

If the facts are to be reconciled with Prof. Zenger's theory this is only possible by adopting the view of Prof. G. H. Darwin, that the original periods of rotation have been lengthened by the action of the satellites (or in the case of the Sun by the planets). For the Sun a period of $12^{d}\cdot52$ gives better results than one of $12^{d}\cdot595$; for Jupiter a period (of semi-rotation) of about $4^{h}\ 46^{m}$ gives much better results than the present one of $4^{h}\ 57^{m}\ 48^{s}$ (the number of semi-rotations being 9, 18, 36, and 84 respectively). Prof. Zenger, may perhaps find this suggestion worthy of examination.

Truly yours,

Dublin, Nov. 2, 1887. W. H. S. Monck.

Drilling small Holes.

Gentlemen,—

In a paper read before the Society at its last meeting, I referred to experiments which necessitated the making of some holes having a diameter of about ·0023 of an inch. It has been suggested that it may interest some of your readers if I give a few particulars concerning the process of their manufacture by Mr. Davis, a watchmaker residing in my neighbourhood, as I believe it is the simplest ever attempted.

Some slightly softened steel wire was reduced to as small a cylinder as possible, using for the purpose a bastard-cut file, having about three hundred cuttings to the inch. A block of boxwood, three inches long and one inch wide, with one of its sides planed as smooth as possible, was fixed in a vice, and a piece of Arkansas stone obtained, two inches long and half an inch wide, having, like the wood, one of its faces ground as smooth as possible. The primitive drill, about half an inch in length, was then by the aid of a little oil rolled to and fro between the wood and the stone, great care being taken that it never remained stationary whilst the stone was moving. If such accident occurs (and it requires a little practice to prevent it) the drill is spoiled, for it will thereby cease to have a truly cylindrical figure, and this will prevent it being ground any further. The rubbing and rolling was continued until the drill became the requisite size. It was then ready to receive its cutting face, which should be lance-shaped like the small drills of watchmakers, and not pointed, for the latter shape, so far as our experience has taught us, will not give a truly circular hole, although I am aware this method has met with more success in other hands.

With regard to the selection of metal to perforate, nothing surpasses nine-carat gold, as it does not readily oxidize, bores clean and without much difficulty. We found it better to commence the hole with a somewhat larger drill, leaving the perforation to be completed by the smaller one, an ordinary stock and tiny bow being used for these purposes. A pointed drill of the same size should be employed to clean the holes, and a few touches of Arkansas stone are sufficient to remove the burr on the underside of the plate. As these holes get filled with dirt in an incredibly short space of time, it is better to clean them immediately before use, as indeed was done in the experiments to which I have referred.

I may perhaps be allowed to add that a hole of the size stated above, when illuminated and viewed through a well-collimated telescope at a distance of about two hundred feet, gives what may be fairly called a point of light, and is surrounded by a series of beautifully defined diffraction rings. EDMUND J. SPITTA.

Ivy House,
Clapham Common, S.W.
1887, Nov.

Break-circuit Chronometers.

GENTLEMEN,—

In the March number of the 'Observatory,' page 140, and in also the September number, page 334, reference is made to the first adaptation of a break-circuit apparatus to a marine chronometer for signalling or chronographic purposes. Professor Young points out in the latter reference what is considered the earliest example of the kind, namely a galvanic attachment adapted to a chronometer by Messrs. Parkinson and Frodsham in 1869. As there appears to be some little interest attached to this question, I would call your attention to a short article written by me on August 27, 1860, entitled "On the application of Galvanic Electricity to Practical Astronomy," and published in vol. v. (page 145) of the Transactions of the Royal Society of Victoria (Australia). At page 150 appears the following:—"Considering the benefits derived from the adoption of chronographic registration in our permanent observatory, I was anxious to devise some means by which it could be also adapted to the shifting observatories used in the geodetic survey. Here, large clocks being of course out of the question, the great difficulty was the mechanical arrangement by which the clock contact could be made with an ordinary marine chronometer—a difficulty so great that, so far as I know, it has not been previously overcome. After several experiments I was enabled to plan an appliance, which has been admirably constructed by a watchmaker at Williamstown, and is found to work perfectly, without interfering with the rate of the chronometer. It consists of an extra wheel of 60 teeth, which is on the seconds' arbour, the teeth conical, with a slight rake, and, as in the astronomical clock, one tooth is cut out as a minute datum. The great delicacy required in adapting contact springs, without producing undue friction, offered the chief obstacle; but by placing the opposing surfaces of the teeth and pallet at the most favourable angle, and arranging so that the slightest lift of the pallet broke contact, instead of making it, the principal difficulty was overcome. The contact here is the reverse of that in the clock; for when the pallet is in the angle between two teeth the spring banks on a platina stud, and the contact is complete; but each passing tooth lifts it sufficiently to break contact for an instant."

A description of a field chronograph follows. The concluding paragraph of the paper states:—

"In conclusion, I would remark that there is nothing original in the chronographs used at the observatory, the clock contact being very similar to the one used at Greenwich and the register is of the most usual form. The portable chronograph, as far as the register is concerned, is a modification of one lately made for the Altona Observatory, the chronometer contact being the only portion which, I believe, has any claim to originality."

It will seem, therefore, that the application of a break-circuit attachment to a marine chronometer must date back to 1860, and I may add that the same chronometer (Molyneaux 1438) is still going with its break-contact springs and has an excellent rate. It has been utilized on several astronomical expeditions, such as the Total Eclipse of 1873 and the Transits of Venus in 1874 and 1882.

Melbourne Observatory,
1887, Oct. 19.

Yours &c.,
R. L. J. ELLERY.

Lalande 26481.

GENTLEMEN,—

Lalande 26481 is No. 148 in Argelander's list of 250 stars (Bonn Observations, vii. 83). The proper motion there given represents Mr. Lenehan's observations as follows:—Calculated: R.A. $14^{\mathrm{h}}\ 25^{\mathrm{m}}\ 2^{\mathrm{s}}{\cdot}58$, Decl. $-15^{\circ}\ 7'\ 11''{\cdot}9$. C−O: R.A. $-0^{\mathrm{s}}{\cdot}09$, Decl. $+2''{\cdot}3$. Other observations are desirable, as the data do not now agree very well.

T. H. SAFFORD.

Williams College Observatory.
Williamstown, Mass.
1887, Oct. 15.

Birmingham 121 *Tauri* alias *Geminorum.*

GENTLEMEN,—

This splendid deep reddish-orange star is given in Webb's 'Celestial Objects' and by Birmingham as a suspected variable; there can be no doubt as to its variability, as it has faded about $\frac{2}{3}$ of a magnitude since December last. Its period is probably long. Its position in Webb is R.A. $5^h\ 39^m$; N.D. 20° 38′.

Yours truly,
T. W. BACKHOUSE.

Sunderland,
1887, Nov. 23.

NOTES.

RESEARCHES ON THE SPECTRA OF METEORITES.—On Thursday, Nov. 17, Mr. Lockyer read a paper bearing the above title before the Royal Society. The paper was a most remarkable one, covering a very extensive field, and it seemed to be felt at the meeting of the Society that the points it embraced were too numerous and too important for any off-hand judgment, whether of approval or the reverse, to be passed upon it. We do not propose at present to do more than give a very brief outline of some of the principal conclusions of the author, but we trust to deal with the subject more at length on a future occasion.

Mr. Lockyer has recently been examining the spectra of meteorites with great care and under various conditions, and the results he has obtained have led him to ascribe the greatest variety of deportment and the widest range of importance to these bodies. For he concludes that:—

"I. All self-luminous bodies in the celestial spaces are composed of meteorites, or masses of meteoritic vapour produced by heat brought about by condensation of meteor-swarms due to gravity.

"II. The spectra of all bodies depend upon the heat of the meteorites, produced by collisions, and the average space between the meteorites in the swarm, or in the case of consolidated swarms, upon the time which has elapsed since complete vaporization. . . . .

"VII. The existing distinction between stars, comets, and nebulæ rests on no physical basis.

"VIII. The main factor in the various spectra produced is the ratio of the interspaces between the meteorites to their incandescent surface.

"IX. When the interspace is very great, the tenuity of the gases given off by collisions will be so great that no luminous spectrum will be produced ('nebulæ' and 'stars' without F bright). When the interspace is less, the tenuity of the gas will be reduced, and the vapours occupying the interspaces will give us bright lines or flutings ('nebulæ' and 'stars' with F bright). When the interspace is relatively small, and the temperature of the individual meteorites therefore higher, the preponderance of the bright lines or flutings in the spectrum of the interspaces will diminish, and the incandescent vapour surrounding each meteorite will indicate its presence by absorbing the continuous spectrum-giving light of the meteorites themselves.

"XI. New stars, whether seen in connexion with nebulæ or not, are produced by the clash of meteor-swarms, the bright lines seen being low-temperature lines of elements the spectra of which are most brilliant at a low stage of heat.

"XII. Most of the variable stars which have been observed belong to those classes of bodies which I now suggest are uncondensed meteor-swarms, or condensed stars in which a central more or less solid condensed mass exists. In some of those having regular periods the variation would seem to be partly due to swarms of meteorites moving around a bright or dark body, the maximum light occurring at periastron.

"XVI. In recorded time there has been no such thing as a world on fire, or the collision of masses of matter as large as the earth, to say nothing of matter as large as the sun; but the known distribution of meteorites throughout space indicates that such collisions form an integral part of the economy of nature. The number of bodies, however, subject to such collisions is extremely small, and must, it would appear, form but a small percentage of the celestial bodies, seeing that they must be dark and cold.

"XVII. *Special Solar Applications.*—*a*. The solar spectrum can be very fairly reproduced (in some parts of the spectrum almost line for line) by taking a composite photograph of the arc spectrum of several stony meteorites, chosen at random, between iron meteoric poles.

"*β*. The carbon which originally formed part of the swarm the condensation of which produced the solar system, has been dissociated by the high temperature brought about by that condensation.

"*γ*. The indications of carbon which I discovered in 1874 ('Roy. Proc. Soc.' vol. 27, p. 308) will go on increasing in intensity slowly, until a stage is reached when, owing to the reduction of temperature of the most effective absorbing layer, the chief absorption will be that of carbon—a stage in which we now find the stars of Class III*b* of Vogel's classification.

"*δ*. At the present time it seems probable that among the chief changes going on in the solar spectrum are the widening of K and the thinning of the hydrogen lines."

Mr. Lockyer regards the line at λ 5000 of the nebulæ not as a line of nitrogen, but as the remnant of the low-temperature fluting of magnesium. Another novelty is his view of stars of the *a* Orionis type, and some Novas, notably Nova Orionis. "These stars are not masses of vapour like our Sun, but clouds of incandescent stones, ... probably the first stage of meteoritic condensation." The spectrum of these bodies is regarded as showing the *bright* bands of carbon together with dark absorption bands due to manganese and zinc. Stars like R Geminorum show a further condensation, and eventually we get to fully formed suns with spectra of the second, or if very large and hot, of the first type. The earlier stage of cooling is seen in stars with spectra of the second type like our Sun, and a later in stars of the fourth type with dark absorption bands due to carbon. Further cooling would leave the star a dark body; and Mr. Lockyer suggests that it is conceivable that such a world may be possibly broken up by a collision into a scattered meteor swarm, and so recommence its course of life afresh, and complete the cycle of its changes.

The Rotation of Jupiter.—Mr. Lynn, in a communication to us on this subject, says that "It seems incredible (as Prof. Hough remarks) that the red spot should have preserved its shape and size unaltered during the whole nine years it has been under observation, if it was simply produced by some gaseous body suspended in the planet's atmosphere." It is probable therefore that it is "a portion of the actual body of Jupiter."

Mr. Denning (see the 'Athenæum' of Oct. 8) has regarded this as impossible, since the period of the red spot has increased by about 7^s since 1879, and this would imply a similar change in the rotation of Jupiter. Mr. Lynn asks, however, if such a change in the rotation period of the planet is really incredible. Mädler and Airy fifty years ago found this period $9^h\ 55^m\ 27^s$ from the observation of two black spots. Prof. Hough and Mr. Denning now give it as $9^h\ 55^m\ 41^s$, an increase of "about 14^s in 52 years, or $0^s{\cdot}27$ per annum. Prof. Hough's observations of the last three years seem to indicate a comparatively small increase, and perhaps a more full discussion of the whole by Mr. Denning and other astronomers may show that the increase does not really exceed the amount I have named."

American Observatories. — The 'Sidereal Messenger' for November gives much interesting information about several of the American Observatories. It appears that Mr. J. A. Schaeberle, the discoverer of the third comet of 1881, and assistant at Ann Arbor Observatory, and Mr. E. E. Barnard, the well-known observer of Nashville, Tenn., have both received appointments as assistants at the Lick Observatory. The instruments of the Dearborn Observatory, Chicago, are to be removed. The trustees of the Lake Forest University had some conference with the Chicago Astronomical Society, with a view to securing their removal to Lake Forest; but it is reported that an offer from the North-western University, Evanston, Ill., a few miles from Chicago, has been accepted, and that the observatory will be re-established there. So far as known, the arrangement is that the University is to erect suitable buildings for the instruments of the Society, but the Society is still to retain its ownership of them. The University will also complete the outfit of minor instruments. It is understood that Gov. Ross, the President of the Board of Trust of the Lake Forest University, is furnishing the financial support for the large observatory contemplated in connection with that institution. The Carleton College Observatory has its new Repsold meridian circle already in place, and Dr. H. C. Wilson is engaged in the determination of the instrumental errors. The 8¼-inch Clark equatoreal has been dismounted and removed to the new observatory, whilst the lenses and tube have been sent to the Clarks, in order that a correcting lens for photography might be adapted to them. This will shortly be completed, and the telescope mounted under the new steel dome made for it by Messrs. Warner and Swasey, and which is already in place; a second dome, ordered of the same firm, is in course of construction. Carleton College Observatory has lost the services of Miss Mary E. Byrd, who has been appointed director of the new observatory at Smith's College, Northampton, Mass. A new astronomical observatory is also being constructed in connection with Iowa College, Grinnell, Iowa; Mr. Grinnell, the founder of the town, providing the funds. An 8-inch Clark equatoreal is to be provided, the building for which is nearly completed. The place Prof. Holden vacated at the Washburn Observatory is being supplied by a double appointment, Prof. Asaph Hall being appointed Consulting Director, and Prof. George Comstock Associate Director. Mr. Charles Rockwell, Tarrytown, New York is about to commence a series of observations with his Almucantar on the Moon in apogee and perigee, to see if any systematic differences in the latitude determinations can be detected in these different positions. The observations are to be carried on for two years.

THE LATE DR. E. LUTHER.—"The Observatory at Konigsberg has experienced a heavy loss in the death on Oct. 16 of one of its oldest directors, Professor Edward Luther. Luther was born on the 24th of February, 1816, at Hamburg, and commenced his studies at Kiel, subsequently prosecuting them under Bessel and Jacobi at Konigsberg, and finally becoming Privat Docent at that place. On Busch's death he assumed, in 1856, the Governorship of the Observatory, in common with the observer Wichmann, and continued in this post until the death of the latter in 1859. On the appointment of C. A. F. Peters to the Observatory at Kiel, Luther succeeded him first as Professor (in extraordinary), then as ordinary Professor in this University. He edited volumes 28, 30, and 31 of the 'Königsberger Beobachtungen' conjointly with Wichmann, and the subsequent six volumes by himself.

"From the observations made with the Repsold meridian-circle which Bessel had left behind, Luther calculated the Declination of the Fundamental Stars. By means of new observations he investigated Argelander's question whether Bessel's Zones contained any constant errors. He carefully compared Bessel's Zones printed in the 'Königsberger Beobachtungen' with the originals, all variations of the same, and all original remarks thereon, with the avowed object of rendering any future reference to the originals unnecessary. From a series of correspondence in the 'Astronomische Nachrichten' he published in volumes 34 and 37 of 'Crelle's Journal' two treatises on the algebraical solution of equations of the fifth and sixth degrees.

"His amiable and philanthropic nature found universal recognition. After protracted sufferings he has passed tranquilly away. With him one of the last of Bessel's school has departed from the roll of the living"*.

Dr. Luther was a Foreign Associate of the Royal Astronomical Society, having been elected in 1864.

PARALLAX OF Σ 2398 †.—In continuance of his researches on the parallax of this double star (see 'Observatory,' Vol. viii. page 315), Dr. Lamp has made, with the refractor and filar micrometer of the Kiel Observatory, a further series of measures of the differences of declination between each component of the pair and each of three neighbouring stars. The results seem to show a sensible relative parallax of one of the comparison stars with reference to the other two. Leaving this point for future investigation, Dr. Lamp finds the mean parallax of $\Sigma_1 = +0''\cdot 3520 \pm 0''\cdot 0140$, and of $\Sigma_2 = +0''\cdot 3548 \pm 0''\cdot 0131$; the mean parallax of the system being $+0''\cdot 353 \pm 0''\cdot 014$.

THE ORBIT OF THE BINARY STAR Σ 3121 ‡.—The orbit of this interesting and difficult double star has recently been computed by M. Celoria of Milan, who has availed himself of the additional materials afforded by an extensive series of measures made by Prof. Schiaparelli. M. Celoria finds a period of 34·65 years, eccentricity $= 0\cdot 30863$ and mean distance $= 0''\cdot 6725$, with time of periastron passage 1878·52. These elements, which are deduced from observations extending from 1861 to 1887, represent the measures fairly well, considering the difficulty of making accurate observations of such a close pair.

BEVIS'S STAR ATLAS.—In the note on this atlas appearing in the 'Observatory' for Nov. 1886, p. 361, it should have been stated that Bevis's constellation figures are copied from those of Bayer's Atlas of 1603. The scale employed is precisely the same, and in almost every instance the figures are reproduced line for

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* Dr. J. Franz in the Astron. Nachr. No. 2810.

† Astron. Nachrichten, No. 2807–2808.

‡ Ibid. No. 2808.

line; the order of the charts is also nea
ever, inserted in addition, in each of
neighbouring constellation figures, so th
different groups might be clearly seen.
more stars than Bayer had done, and
smaller and neater symbols.

The Spectra of Oxygen and Carbo
the Sun *.—Profs. Trowbridge and H
engaged in the attempt to discover if th
any traces of the presence of the two im
and carbon. With respect to oxygen
reference to the researches of Dr. H. I
Prof. J. C. Draper (see 'Observatory,' V
Vol. iii. p. 66), and their conclusion is
tors used too low a dispersion. With on
concave gratings of, apparently, about 2
a ruled surface of 6 inches by 2 inches,
of much greater dispersion than that D
and under these more favourable circ
lost of the bright bands which seemed, a
upon his photographs, and they record
spectrum on every available day for ne
finding a line which could be pronoun
brighter than its neighbours, "and it
photograph is the best of photometer
therefore conclude that Dr. H. Drape
oxygen in the solar spectrum was a n
reject his brother's identification of the
number of feeble dark lines, as rendere
any systematic connection between the
certainly in error in supposing that D
been universally accepted in this count
case, and principally on the very ground
and Hutchins now bring forward, *i. e.*
the appearance of bright bands is lost,
that the localities selected by Dr. H. D
than the neighbouring portions of th
Vol. iii. p. 118; Monthly Notices, Vol.

For the carbon spectrum Profs. Tro
a concave grating of 21 feet 6 inches r
the inch, and their experiments led th
details of the ground upon which they
well-known fluted spectrum of carbon i
as "self-reversal," the dark intervals be

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[*] Amer. Journ. of Science, 1887, Oct. & N
Arts and Sciences, Vol. xxxiii.

lines of the flutings being due to a reversal of the lines of carbon by its own vapour. And they find in the solar spectrum dark lines following each other in rhythmical series, and corresponding —not, as Mr. Lockyer found many years ago, to the bright lines of the carbon flutings *,—but to these dark interspaces. It is clear that this claim is one to which, however well founded it may prove to be, spectroscopists generally will not give their adhesion until the evidence upon which it is founded has been actually laid before them.

NEW VARIABLE IN LIBRA †.—Dr. Bauschinger having observed a star which, though it appears in Lamont's zones, is not in the southern Durchmusterung, wrote to Dr. Schönfeld on the matter and suggested that the star was probably variable. Dr. Schönfeld replied that he had observed a star near the place given by Lamont on two if not three occasions, but that he had hesitated to identify it with Lam.$_3$ 1875, on account of the numerous errors in the Munich zones, and he had marked the star for further observation. Its identity was, however, now established, and the following addition should be made to the Bonn. Beob. Vol. viii. after the star -5° No. 4028:—"Var. $15^{\mathrm{h}}\ 4^{\mathrm{m}}\ 2^{\mathrm{s}}\cdot5$, $-5^\circ\ 27'\cdot5$ M." The star will probably repay watching by those who make variable stars a study.

THE VARIABLE STAR, U OPHIUCHI ‡.—Mr. S. C. Chandler has recently investigated the light-curve of this specially interesting variable, of all the Algol type stars the one with the shortest period and most rapid fluctuations of light, and he has brought together all the available estimates of its magnitude, including many made before its variability was discovered. The result of his discussion renders it probable that the period has undergone a slight shortening, so that the observations are well represented by the following elements:—1884, Jan. 1, $0^{\mathrm{h}}\ 54^{\mathrm{m}}\ 43^{\mathrm{s}}\cdot6$, Paris M.T., $+20^{\mathrm{h}}\ 7^{\mathrm{m}}\ 41^{\mathrm{s}}\cdot6\ (E-1070)-0^{\mathrm{s}}\cdot0002\ E^2$, the period being thus assumed to shorten with each recurrence by $0^{\mathrm{s}}\cdot0004$. The light-curve also shows a curious irregularity shortly after minimum, for whilst the diminution of light previous to minimum is very regular, the recovery afterwards is not so, there being a well-marked retardation in the rate of increase about half an hour after minimum is passed. Schönfeld's investigation of the light-curve of S Cancri brought out a similar peculiarity which has also been remarked in Algol. It is clearly of importance to ascertain whether this irregularity is merely subjective or is really a feature of the star's variation, as it has an important bearing on the

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* Proc. Royal Soc. Vol. xxvii. p. 308.

† Astron. Nachr. No. 2810.

‡ Gould's Astron. Journ. Nos. 161 and 162.

satellite theory of Algol and stars of the same type, and we tr that observers of variables will give the subject their espe attention, not with one star of the type alone, but with all.

THE TWO NEW ALGOL-VARIABLES Y CYGNI AND R CA MAJORIS[*].—Mr. Chandler gives the following ephemeris for minima of the two new Algol-variables recently discovered:—

Y Cygni; R.A. $20^{h}\ 46^{m}\ 16^{s}$, Decl. $+34^{\circ}\ 7'{\cdot}0$.

	h	m		h	m
Dec. 2....	10	29·7	Dec. 15....	22	0·9
3....	22	26·5	17....	9	57·7
5....	10	23·3	18....	21	54·5
6....	22	20·1	20....	9	51·3
8....	10	16·9	21....	21	48·1
9....	22	13·7	23....	9	44·9
11....	10	10·5	24....	21	47·7
12....	22	7·3	26....	9	38·5
14....	10	4·1	27....	21	35·3

R Canis Majoris, R.A. $7^{d}\ 13^{m}\ 49^{s}$, Decl. $-16^{\circ}\ 9'{\cdot}7$.

	h	m		h	m
Dec. 1....	13	20·1	Dec. 10....	15	27·7
2....	16	36·0	11....	18	43·3
3....	19	52·0	12....	21	59·2
4....	23	7·9	14....	1	15·2
6....	2	23·8	15....	4	31·1
7....	5	39·7	16....	7	47·0
8....	8	55·6	17. ..	11	2·9
9....	12	11·6	18....	14	18·8

The star-places are given for 1875·0. The times are expre in Greenwich Mean Time. The period of Y Cygni (Observat Vol. x. pp. 110, 142, 335) has proved to be about 36 hours, stead of about 3 days; and that of R Canis Majoris (Observat Vol. x. p. 364) to be about 27 hours, as Mr. Sawyer suspecte first.

THE NATAL OBSERVATORY.—The Report for 1886 of the Su intendent of this Observatory has reached us, and we learn f it that during 1886 the work of the Observatory was al confined to the meteorological side. The staff had been reduce two, viz. Mr. Neison and Mr. Grant his assistant. As the for was seriously ill during the early part of the year, and was ab in England during the summer and autumn, Mr. Grant practically alone. The equatoreal was not used, as the microm and other accessories had to be taken to England for repairs ration. The transit instrument had been employed on ordinary ine work, the new collimator was almost completed at the of the report, and the new micrometer had been returned 1 Messrs. Simms. A number of observations of differences .D. of selected pairs of stars for determination of latitude were ired in the early part of the year, but the accidental breaking he micrometer-wires brought the work to a close. The con-ion of the fundamental declinations of the Star catalogues of Northern and Southern Observatories by means of observa-s of differences of Z.D. between 32 selected stars passing the zenith of the great Northern Observatories with corre-ding Southern Circumpolar stars has been commenced and form a special item in the programme of the Observatory.

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[*] Gould's Astron. Journ. No. 162.

ROPER MOTIONS OF STARS.—Herr N. M. Kam, in No. 2806 of 'Astronomische Nachrichten,' has brought together numerous for the determination of the proper motions of some 16 stars, first two (Lal. 28607 and Lal. 28644), for which he has gathered h material, being discussed in particular detail. The remaining tars are from the Helsingfors zones, their positions in which r considerably from those assigned to them in the Catalogue, d on observations scattered through the 'Astronomische hrichten.' The results are as follows:—

Star.		Proper Motion in R.A.	Proper Motion in Decl.
		s	″
Lal. 28607		−0·0793	−0·278
Lal. 28644		+0·0034	−0·105
DM.+61° No.	152	+0·0098	−0·057
+59	220	+0·0127	−0·044
+63	577	+0·0374	−0·191
+57	954	+0·0086	−0·170
+59	1183	−0·0142	−0·046
+62	1192	+0·0159	+0·034
+56	1568	−0·0224	−0·034
+56	1569	−0·0258	−0·046
+61	1353	−0·0391	+0·070
+56	1780	−0·0021	−0·124
+60	1589	+0·0121	−0·138
+61	1571	+0·0134	+0·057
+61	1574	+0·0210	+0·411
+58	1844	−0·0183	−0·165

HE COUNCIL OF THE R.A.S.—We have been requested to print following table, showing the number of years during which the respective Members of the present Council have held continuous office :—

Name.	Years.	Name.	Years.
Prof. Cayley	30	Mr. Capron	5
Prof. Adams	28	Col. Tupman	4
Dr. Huggins	24	Mr. Maunder	3
Mr. Dunkin	20	Gen. Tennant	3
Mr. Ranyard	16	Lord Crawford	2
Mr. Glaisher	14	Mr. Chambers	2
Mr. Knobel	12	Capt. Noble	2
Mr. Hind	11	Capt. Abney	1
Mr. Common	9	Rev. S. J. Perry	1
Mr. Christie	8	Mr. Turner	1
Mr. Stone	8		

THE LATE DR. H. C. F. C. SCHJELLERUP *.—The Royal Astronomical Society has lost another of its distinguished Foreign Associates by the death of Dr. H. C. F. C. Schjellerup. "Schjellerup was born Feb. 8, 1827, at Odense, and after an ordinary education was apprenticed to a clockmaker. This kind of work, however, did not coincide with his wishes, and he managed during his leisure hours to study such scientific books as the library of the place afforded, and with such effect that in 1847 he could enter the Polytechnic School at Copenhagen, where his gifts and diligence were soon noticed by Oersted, who interested himself in him, and introduced him to Heiberg, an amateur astronomer. In 1850, Schjellerup had completed his studies at the Academy, and in 1851 he was appointed as Observer in the Observatory at Copenhagen. Some years later he became teacher of Astronomy and Mathematics at the College for Naval Officers, and also teacher of drawing in the Polytechnic School. These positions he held to the day of his death, which occurred Nov. 13, 1887.

"Occupied continuously with the regular time service, his observing work was necessarily limited. In the astronomical world he became known by his computations of orbital elements, and his work on Tycho Brahe's original observations in order to compute the orbit of the comet of 1580. At the new observatory he was charged with Meridian-Circle Observations, in which he showed great energy, both in observing and reducing his catalogues. He also made researches in the proper motions of stars, and published a catalogue of such in the 'Astronomische Nachrichten,' where also is the catalogue of red stars by him, by which his name has been perhaps most widely known.

"On Olufsen's death the question arose as to Schjellerup's claim to the professorship, and he was reproached for an alleged deficiency in regular classical studies. These objections were very unreason-

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* Dr. Thiele, in Astron. Nachr. No. 2814.

able, as he was singularly proficient in Chinese and Arabic, as he showed in the use he made of them in his work on Ulugh Beigh's star-catalogue. His later studies, in which he particularly engaged himself in lunar theory, were pursued more and more for his own personal development, and he cared for little other interest or reward than that of his work itself. His amiability, sagacity, and delicacy of feeling had a great and beneficent influence on his many pupils in the Navy and in the Polytechnic School. His studies have perhaps less importance for astronomy than they might have had under more favourable circumstances; yet no one ever went to him in vain for advice and assistance, for he possessed a great store of information, and was always willing to share it with others. A wide circle of friends will deplore his loss."

PROBABLE NEW CLASS OF VARIABLE STARS.—The Rev. T. E. Espin, in Circular No. 18 of the Wolsingham Observatory, states that "Observations made here seem to indicate a new class of Variable Stars with these characteristics:—Period, Irregulár; Variation, 1½ mag.; Spectrum, IV. type.

"The stars 19 Piscium; Birmingham, 277, 521, 535, 541; Espin, 116, 154; belong to this class, and perhaps Birmingham, 85, 120, 121, 240, 290, 418, 464, 483, 502. The stars of this class are subject to rapid and uncertain changes in brightness."

NAMES OF MINOR PLANETS.—No. 268 has received the name of Adorea, and No. 270 of Anahita.

Ephemeris for Olbers' Comet[*].

By O. TETENS.

For Berlin Midnight.

1887.	R.A. h	m	s	Decl. °	′	Log r.	Log Δ.	Brightness.
Dec. 1..	15	26	36	+7	10·9	0·1594	0·3354	0·84
3..	15	32	7	6	34·7			
5..	15	37	31	5	59·5	0·1692	0·3417	0·78
7..	15	42	49	5	25·1			
9..	15	48	0	4	51·6	0·1790	0·3478	0·73
11..	15	53	4	4	19·1			
13..	15	58	2	3	47·5	0·1890	0·3537	0·68
15..	16	2	54	3	16·9			
17..	16	7	41	2	47·2	0·1990	0·3593	0·63
19..	16	12	21	2	18·4			
21..	16	16	56	1	50·5	0·2090	0·3645	0·59
23..	16	21	25	1	23·5			
25..	16	25	48	0	57·3	0·2190	0·3695	0·55
27..	16	30	6	+0	31·9			

[*] Astron. Nachr. No. 2813.

Ephemeris (*continued*).

	R.A.			Decl.				Bright-
1887.	h	m	s	°	′	Log *r*.	Log Δ.	ness.
Dec. 29..	16	34	19	+0	7·4	0·2290	0·3741	0·51
31..	16	38	27	−0	16·2			
Jan. 2..	16	42	30	0	39·0	0·2389	0·3783	0·48
4..	16	46	27	1	1·2			
6..	16	50	20	−1	22·7	0·2486	0·3821	0·45

The correction to the above ephemeris is given by a Vienna observation on Oct. 21 as R.A. $+3^s$, Decl. $+0'{\cdot}2$, and it will probably become slowly larger. The brightness of the comet on Aug. 27 is taken as unity.

EDITORIAL NOTE.

With this Number of The Observatory its present Editors withdraw from its management. Before doing so they would wish to convey their most sincere thanks to the many friends who have so ably and willingly assisted them in the literary and scientific portion of their work, and to the constantly increasing circle of subscribers, so many of whom have promoted by their recommendations its yet wider circulation. It has been the aim of the Editors to make the 'Observatory' as useful to its readers as possible, and they desire to put on record their grateful appreciation of the generous spirit in which their efforts have been judged. Relying on the kind reception which has ever been accorded to them, they would beg from their friends yet one further favour—that they would extend to the future Editors, Messrs. Turner and Common, the same hearty and liberal support which they have shown to the present; and with this last request they would retire, regretting indeed the interruption of an intercourse which has been only a pleasant one, but gratified to know that they leave the 'Observatory' on a sound and satisfactory basis both as to position and finance, and that they resign it into hands which will not fail to preserve and increase whatever influence and reputation it may have secured in the past.

ERRATUM in No. 129.

Page 396, line 5 from foot, *for* $\pm 0''{\cdot}034$ *read* $\pm 0^s{\cdot}034$.

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ontains a complete Astronomical Calendar, giving the times of rising setting of the Sun and Moon, the longitude of the Moon's terminator, uation of Time, and Sidereal Time at Noon for each day; the principal teor-radiants for each month; ephemerides for the planets and for sical observation of the Sun and Jupiter; information respecting the ipses of the year; tables of the occultations visible at Greenwich, and of phenomena of Jupiter's satellites; ephemerides, with diagrams, of the ellites of Saturn, Uranus, and Neptune; a catalogue of variable stars, th times of maxima and minima; a classification of all the brighter rs according to their spectra, with the positions for 1887 of those with most remarkable spectra; a list of Binary Stars with recent obsertions; and a catalogue of the positions of the principal lunar craters.

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PARIS INTERNATIONAL EXHIBITION, 1867—"The Gold Medal for the best Telescope, and the Silver Medal for the best Photographic Lens."

PHILADELPHIA EXHIBITION, 1876—"Highest Award for Telescopes, Microscopes, Photographic Lenses, and Apparatus."

PARIS INTERNATIONAL EXHIBITION, 1878—"The Cross of the Legion of Honour and Two Gold Medals." Exhibit: Telescopes, Microscopes, Photographic Lenses, &c.

Descriptive Catalogue of Telescopes, Microscopes, Photographic Lenses, &c., on application.

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